Original Article

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Severity and Association of Hypertensive Retinopathy in Patients with Chronic Kidney Disease Stages 3–5

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ABSTRACT

Background: *Chronic Kidney Disease (CKD) is strongly associated with microvascular complications and Hypertensive Retinopathy (HR) is one of the key ocular manifestations. Since both the renal and retinal vasculatures are highly susceptible to long-standing hypertension, the severity of HR may reflect the progression of CKD. However, data are limited regarding the association between CKD stages and HR severity in our setting. To evaluate the severity and association of hypertensive retinopathy among patients with CKD stages 3–5 this study was done.*

Materials and methods: *This cross-sectional study was conducted among 200 patients with CKD stages 3–5. Baseline demographic and clinical data, including age, gender, BMI, duration of hypertension and diabetes, and blood pressure measurements, were recorded using convenient sampling. Ocular examination included assessment of Best Corrected Visual Acuity (BCVA) using the LogMAR scale and grading of HR based on standard classification.*

Results: *In this study of 200 CKD patients, the majority were over 50 years of age, male and overweight with a long-standing history of hypertension and diabetes. Distribution across CKD stages showed nearly equal proportions in stages 3, 4 and 5. Visual assessment revealed a significant decline in best corrected visual acuity with CKD progression, as poorer vision was more frequent in stages 4 and 5 compared to stage 3. Retinopathy assessment showed hypertensive retinopathy in more than half of the patients. Importantly, the severity of hypertensive retinopathy showed a significant association with CKD stage with advanced stages predominantly exhibiting higher grades (Grade 3–4) compared to earlier stages. These findings confirm that progressive CKD is strongly linked with worsening visual outcomes and more severe hypertensive retinopathy.*

Conclusion: *The study demonstrated a significant association between advancing CKD stage and worsening severity of hypertensive retinopathy. Patients in CKD stages 4 and 5 exhibited higher grades of HR and poorer visual outcomes compared to those in stage 3. These findings suggest that retinal examination may serve as a simple, non-invasive marker of systemic vascular damage and should be integrated into routine monitoring of patients with CKD.*

Key words: Chronic kidney disease; Hypertensive retinopathy; Ocular manifestations; Visual assessment.

Introduction

Retinopathy refers to damage of the blood vessels in retina. It is one of the leading causes of preventable blindness. It is one of the most common microvascular complications associated with diabetes. Loss of pericytes, which are the cells of Central Nervous System (CNS) that associate with capillaries to provide vascular stability is an early sign of retinopathy. Retinopathy is often asymptomatic in its most treatable stage and delay in diagnosis can result in significant increase in patients' risk of visual loss. Ocular condition is also an indicator of metabolic control of disease process.[1]

Chronic Kidney Disease (CKD) stages 3–5, defined by progressively declining estimated Glomerular Filtration Rate (eGFR) is closely intertwined with vascular dysfunction including Hypertensive Retinopathy (HR) an ocular manifestation of systemic hypertension. In nondiabetic CKD populations, the overall prevalence of hypertensive retinopathy ranges notably high, for example, in one study, 60% of patients had hypertensive retinopathy, with increasing from 62.5% in stage 3 to 75.6% in stages 4–5.[2]

HRwas present in 60% of CKD patients, increasing with disease stage: 34.3% in stages 1–2, 62.5% in stage 3, and 75.6% in stages 4–5.[3]

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In Bangladesh, a hospital-based cross-sectional study reported a prevalence of 29.9% among hypertensive adults (Grade I most common at 14.7%).[4] As an emerging public health issue, CKD is predicted to be the fifth most common cause of death worldwide by 2040.[5] A recent meta-analysis showed an overall prevalence of CKD in Bangladeshi people as 22.48%, which was higher than the global prevalence of CKD 8.54% in 2021.[6]

HR progresses through well-defined stages: initial vasoconstriction causing arteriolar narrowing, followed by sclerosis (Intimal thickening and medial hyperplasia), manifesting as "Copper wiring" and arteriovenous nicking and in advanced stages, exudative changes, including hemorrhages, cotton-wool spots hard exudatesand optic disc edema due to breakdown of the blood-retinal barrier and endothelial dysfunction.[3]

Patients with CKD had a significantly higher prevalence of retinopathy compared with patients without CKD.[7] Retinal neuronal impairment is present in early stages of CKD (Stages 1–2) and it is associated with accumulation of uremic toxins and higher Urine Albumin-Creatinine Ratio (UACR) while retinal microvascular hypoperfusion, which is associated with worse eGFR, was observed in relatively advanced stages of CKD (Stages 3–5).[8] Presence of retinopathy, visual acuity impairment and patient co-morbidities lead to significant impairment of both the physical and mental components of health-related quality of life of CKD patients with retinopathy.[9]

Observational study at a tertiary care hospital (2025) found that higher grades of HR were more frequently observed in CKD stage V compared to earlier stages. Notably, Grade III and even Grade IV HR, indicators of severe retinal damage—were most prevalent in patients with advanced CKD, emphasizing a clear gradation of ocular damage paralleling renal dysfunction.[10] Additionally, evidence from a case–control study using Optical Coherence Tomography Angiography (OCTA) illustrated microvascular changes in the retinal layers of CKD patients (stages 3–5). Specifically, reduced vessel density in both superficial and deep vascular plexuses was observed, with worse blood pressure control, especially elevated systolic pressurebeing associated with greater microvascular impairment.[11]

Materials and methods

This cross-sectional observational study included 200 hospitalized CKD patients at the Departments of Ophthalmology and Nephrology, Chittagong Medical College Hospital (CMCH), between April 2023 and September 2024. Ethical approval was obtained from the institutional review boardand informed written consent was taken from all participants. Demographic and clinical data were collected through face-to-face interviews and medical record reviews. Anthropometric measurements (Height, weight, BMI) blood pressure (Measured in the right arm while seated) and visual acuity (Using illuminated Snellen's chart, converted to LogMAR) were recorded. Anterior segment evaluation was done via slit-lamp to exclude hazy media and dilated fundus examination was performed using direct and indirect ophthalmoscopy. Patients with retinopathy underwent color fundus photography for documentation. Hypertensive retinopathy severity was graded using the Keith–Wagener–Barker classification.

Inclusion criteria

- Hospital admitted patients with CKD (Stage 3-5).
- Age >18 years.

Exclusion criteria

- Patient with CKD stage 1,2
- Patients in whom fundus could not be assessed due to hazy media- mature cataract, vitreous haemorrhage etc.
- Patients with previous history of vitreo-retinal surgery, anti-VEGF and laser treatment.
- Patients with CKD stage 3-5 without retinopathy.
- Patients on renal replacement therapy.

Data analysis involved both descriptive and inferential statistics. Baseline demographic and clinical variables were summarized using mean ± standard deviation for continuous variables, while categorical variables were expressed as frequency and percentage. Participants were categorized according to CKD stages, duration of hypertensionand presence of retinopathy. Associations between CKD stages and visual acuity (LogMAR BCVA categories), as well as hypertensive retinopathy grading, were assessed using the Chi-square test. Statistical significance was determined through p-values derived from these tests. This approach allowed evaluation of the distribution of variables and their relationship to disease severity.

Results

Table I Baseline Demographic variables among study participants (n=200)

Variable		n (%)	Mean ± SD	Range
Age (years)	≥50	135 (67.5%)	53.26 ± 9.24	35–78
	<50	65 (32.5%)		
Gender	Male	124 (62%)		
	Female	76 (38%)		
BMI (kg/m²)	≥25	175 (87.5%)	27.41 ± 1.97	23–33.30
	<25	25 (12.5%)		

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From above table, among the study population the mean age was 53.26 ± 9.24 years with male predominance (62%). More than half of the patients (67.5%) were above 50 years of age. The mean BMI was 27.41 ± 1.97 kg/m². 87.5% of patients had BMI ≥25 kg/m², overweight.

Table II Stage-wise distribution of CKD patients (n=200)

Stage of CKD	n (%)
CKD Stage 3	55 (27.5%)
CKD Stage 4	72 (36%)
CKD Stage 5	73 (36.5%)

Table II depicts that among the study population, 27.5% of patients were CKD stage 3, 36% were CKD stage 4 and 36.5% were CKD stage 5.

Table III Duration and measurement BP of study population (n=200)

Variable		n (%)	Mean ± SD	Range
Duration of HTN (Years)	<5	19(11.3%)	10.68 ± 5.2	1–25
	5-10	69 (41.1%)		
	>10	80 (47.6%)		
Systolic Blood Pressure (mmHg)		149.87 ± 15.51		
Diastolic Blood Pressure (mmHg)		89.82 ± 8.51		

Table III shows 47.6% patients had >10 years history of HTN with a mean duration of 10.68 ± 5.2 years. Mean SBP was 149.87 ± 15.51 mmHg and mean DBP was 89.82 ± 8.51 mmHg.

Table IV Association of LogMAR score of BCVA with CKD stages (n=200)

	LogMAR score of BCVA			
CKD Stage	Good vision <0.5	Moderate vision 0.6-1	Poor vision >1.1	p-value
CKD Stage 3	44 (22.0%)	10 (5.0%)	1 (0.5%)	
CKD Stage 4	48 (24.0%)	26 (13.0%)	8 (4.0%)	0.001
CKD Stage 5	33 (16.5%)	13 (6.5%)	17 (8.5%)	
Total	125 (62.5%)	49 (24.5%)	26 (13.0%)	

Table IV shows a significant association between advancing stages of CKD and BCVA (p< 0.001). In CKD stage 3, 22.0% of patients had good vision, with minimal cases of poor vision 01(0.5%). As CKD progressed, visual acuity worsened, with 24.0% of patients in CKD stage 4 had good vision, 13.0%moderate and 4.0% poor vision. CKD stage 5 showed the most deterioration, with only 16.5% had good vision and 8.5% experienced poor vision.

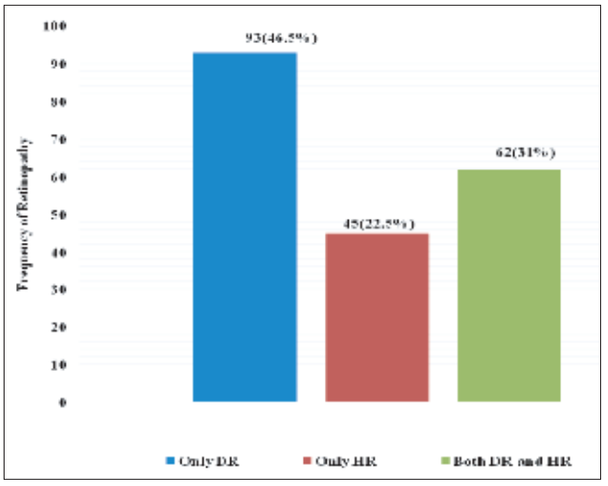

Figure 1 Frequency distribution of retinopathy among the study population (n-200)

Among the study population 93(46.5%) had only Diabetic Retinopathy (DR), while 45(22.5%) patients had only Hypertensive Retinopathy (HR). Both DR and HR were present in 62 (31%) patients.

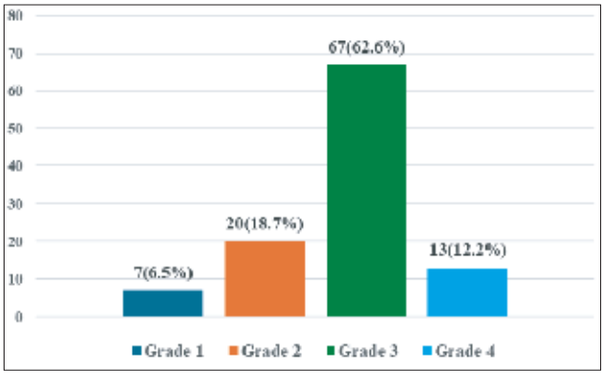

Figure 2 Frequency distribution of HR grading among patients with HR (n=107)

Among 107 HR patients, 7 (6.5%) had Grade 1, 20 (18.7%) had Grade 2, 67 (62.6%) had Grade 3 and 13 (12.2%) had Grade 4.

Table V Distribution of CKD patients on HR grading (n=107)

	No of patients on HR grading					
CKD Stage	Grade 1	Grade 2	Grade 3	Grade 4	Total	p-value
Stage 3	5 (4.7%)	15 (14.0%)	4 (3.7%)	1 (0.9%)	25 (23.4%)	0.0001
Stage 4	1 (0.9%)	3 (2.8%)	27 (25.2%)	7 (6.5%)	38 (35.5%)	
Stage 5	1 (0.9%)	2 (1.9%)	36 (33.6%)	5 (4.7%)	44 (41.1%)	
Total	7 (6.5%)	20 (18.7%)	67 (62.6%)	13 (12.1%)	107 (100.0%)	

There is a progressive worsening of hypertensive retinopathy with advancing CKD stage. 27(25.2%) patients with CKD stage 4 and 36(33.6%) in stage 5 had Grade 3 HR compared to 4 (3.7%) in stage 3.

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Discussion

This study reveals a clear progression of hypertensive retinopathy (HR) severity alongside advancing CKD stages, with more pronounced retinal changes observed in stages 4 and 5. These findings align well with previous research. Prasai et al. reported that the severity of hypertensive retinopathy significantly increased with CKD stage, with advanced disease (OR = 2.98; P = 0.014), mirroring our observation of greater retinal damage in later CKD stages.[12]

Among the study population 93(46.5%) had only Diabetic Retinopathy (DR), while 45(22.5%) patients had only HR. Both DR and HR were present in 62 (31%) patients (Figure 1).

Among hypertensive nondiabetic CKD patients, HR was highly prevalent and severity increased with worsening CKD stags showing that even without diabetes, CKD plus hypertension yields significant retinal damage, consistent with substantial HR component and supporting the idea that CKD intensifies hypertensive microangiopathy.[12]

A population study found hypertension and albuminuria independently associated with retinopathy, highlighting the same systemic drivers (BP load, renal injury) that can produce overlapping DR and HR in clinical cohorts like this research.[13]

The findings of (Table IV) demonstrate a progressive decline in visual acuity as chronic kidney disease advances. In CKD stage 3, most patients retained 44(22.0%)good vision with 01(0.5%) isolated cases of poor vision, reflecting that early renal impairment is less likely to be accompanied by severe ocular complications. However, in stage 4, 48(24%) patients maintained good vision, and a greater proportion developed moderate 26(13%) or poor 8(4%) visual outcomes. This decline became even more pronounced in stage 5, where 33(16.5%) patients preserved good vision and a substantial fraction 17(8.5%) suffered from poor vision. This stepwise deterioration suggests that worsening renal function is closely linked to microvascular compromise in the retina. Pathophysiological mechanisms such as chronic hypertension, endothelial dysfunction and accumulation of uremic toxins likely exacerbate retinal vascular damage, accelerating visual impairment. Similar trends have been observed in other studies, where advanced CKD was associated with higher prevalence and severity of retinopathy and poorer vision.

A cross-sectional study conducted in Nepal demonstrated a significant positive correlation between the severity of hypertensive retinopathy and advancing CKD stages. Patients exhibiting HTR with visual morbidity had nearly threefold higher odds of being in advanced CKD (OR = 2.98, p = 0.014) compared with those without such complications.[14]

There was a progressive worsening of HR grades with advancing CKD stage. Patients with CKD stage 4–5 are more likely to develop severe hypertensive retinopathycompared to stage 3. Retinal examination may serve as a non-invasive marker of systemic vascular damage and help assess disease severity in CKD patients (Table V).

Additionally, evidence from a case–control study using Optical Coherence Tomography Angiography (OCTA) illustrated microvascular changes in the retinal layers of CKD patients (Stages 3–5). Specifically, reduced vessel density in both superficial and deep vascular plexuses was observed, with worse blood pressure control—especially elevated systolic pressurebeing associated with greater microvascular impairment.[15]

The increased likelihood of HR was seen with worsening CKD, compared to stage 3, those in stage 4 had significantly elevated odds (OR = 4.28; 95% CI: 1.56–11.74, p = 0.005) and those in stage 5 faced even higher odds (OR = 8.62, 95% CI: 3.56–20.87, p < 0.001).[16]

Limitation

This study has certain limitations that should be acknowledged.

First, being a single-center, cross-sectional investigation, the findings may not be fully generalizable to broader populations and cannot establish causality between CKD progression and hypertensive retinopathy severity.

Second, many patients in the study also had long-standing diabetes and diabetic retinopathy, which may have acted as confounding factors and influenced retinal changes, making it difficult to attribute all findings exclusively to hypertensive retinopathy.

Finally, the absence of longitudinal follow-up restricts the ability to assess the progression of hypertensive retinopathy over time, limiting insights into temporal relationships between CKD advancement and retinal deterioration.

Conclusion

These data underscore that HTR prevalence and severity escalate across CKD stages 3–5, underpinned by microvascular dysfunction and confounded by hypertension severity and metabolic factors. Recognizing the interplay between renal and retinal health highlights the importance of interdisciplinary monitoringintegrating ophthalmic screening in CKD management to detect progressive microvascular damage and mitigate vision-threatening complications that will lessen the morbidity and mortality of the patients.

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Recommendation

Regular retinal examinations should be incorporated into the clinical care of CKD patients, particularly in stages 4 and 5, to allow early detection and management of hypertensive retinopathy and other microvascular complications.

Strict blood pressure control, especially targeting systolic hypertension, should be emphasized as a priority in CKD patients to reduce the risk and severity of hypertensive retinopathy.

Nephrologists, ophthalmologistsand endocrinologists should collaborate in the management of CKD patients, particularly those with multiple comorbidities such as diabetes and hypertension, to provide holistic care and minimize microvascular damage.

CKD patients should be counseled about the risk of ocular complications, encouraged to undergo regular eye checkups, and educated about the importance of lifestyle modification and medication adherence.

Disclosure

The authors declare no conflict of interest.

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