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Role Of Orbital Arterial Color Doppler In Chronic Kidney Disease Patients With And Without Glaucoma

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Abstract

Introduction: *Glaucoma is disease characterized by optic nerve damage where vascular regulation is a strong impacting factor. This study investigates the role of Color Doppler Imaging in the early diagnosis and prediction of progression of glaucoma in patients with chronic kidney disease by analysing changes in ocular blood flow and vascular resistance.*

Materials and methods: *Prospective study done between 2024 and 2025 at RL Jalappa hospital. CDI assessed ocular blood flow in 50 CKD patients with glaucoma, 50 CKD patients without glaucoma, and 50 healthy controls. Measurements included peak systolic velocity (PSV), end-diastolic velocity (EDV), and resistive index (RI) in the central retinal and posterior ciliary arteries. Data were compared across groups to detect significant differences and correlated with OCT results. Statistical analysis used ANOVA test*

Results: *In 50 CKD patients and 50 healthy controls, CDI revealed a 20% reduction in blood flow velocities and a 26% increase in vascular resistance in CKD patients with glaucoma. The Resistive Index (RI) increased by 30% in these patients, aligning with OCT and visual field findings.*

Conclusion: *CDI is a highly effective tool for early glaucoma detection and ongoing monitoring. It delivers critical insights into vascular changes that precede structural damage, facilitating prompt intervention and treatment approaches*

Key words: *Chronic Kidney disease, Glaucoma, Orbital arterial blood flow, Color Doppler imaging, Ocular blood flow, Hemodynamics.*

INTRODUCTION

Glaucoma is a neurodegenerative condition characterized by retinal ganglion cell (RGC) loss, optic nerve damage, and progressive, painless peripheral vision loss that can lead to blindness if untreated.[1] Its silent progression often delays diagnosis.

Although elevated intraocular pressure (IOP) remains the main risk factor, glaucoma involves multiple elements like vascular issues, impaired RGC axon transport, oxidative damage, and genetics.[2,3] Optic nerve injury stems from their combined effects, not one alone. The vascular hypothesis emphasizes poor ocular blood flow as a driver, evident in normal-tension glaucoma (NTG) and cases progressing despite IOP control via drugs, lasers, or surgery.[4,5]

Links between chronic kidney disease (CKD) and glaucoma are gaining attention, especially vascular changes that alter eye blood flow and worsen nerve damage. Tools like Color Doppler Imaging (CDI) detect lower blood flow speeds in glaucoma patients, bolstering its diagnostic promise and underscoring blood flow's role.[6] Ongoing studies probe vascular risks to clarify disease mechanisms.

MATERIALS AND METHODS

This prospective, interventional hospital-based study was conducted in the Department of Ophthalmology and Radiology at R.L.J. Hospital and Research Centre, Kolar attached to Sri Devaraj Urs Medical College. After obtaining approval from the Institutional Ethics Committee (No. CEC/S/PG/77/2024-25) CDI was done in patients with CKD between 2024 to 2025, reports were reviewed and analysed.

A KDIGO (Kidney Disease: Improving Global Outcomes) classification staging system was used to stage chronic kidney disease.

Study Population and Assessments

CKD patients (stages 1–5) were divided into Group A (glaucomatous) and Group B (non-glaucomatous) based on pre-study vision exams, including IOP measurement, gonioscopy, and fundoscopy.

CDI targeted the ophthalmic artery (OA), central retinal artery (CRA), and posterior ciliary arteries (PCA) using a 5–12 MHz transducer on a GE VOLUSON E6 machine. Key parameters included resistivity index

CDI Parameter	Correlation with RNFL (r-value, CKD + Glaucoma)	p-value	Correlation with RNFL (r-value, CKD - Glaucoma)	p-value
PSV OA	0.42	0.02*	0.48	0.01*
EDV OA	0.51	0.004*	0.55	0.002*
RI OA	-0.38	0.04*	-0.41	0.03*
PSV CRA	0.45	0.01*	0.52	0.004*
EDV CRA	0.49	0.006*	0.57	0.002*
RI CRA	-0.36	0.05	-0.39	0.04*
PSV PCA	0.4	0.03*	0.46	0.01*
EDV PCA	0.47	0.008*	0.54	0.003*

(RI), peak systolic velocity (PSV), and end-diastolic velocity (EDV). Findings were correlated with fundoscopy and spectral domain OCT-measured retinal nerve fiber layer (RNFL) thickness.

Inclusion: CKD stages 1–5; age ≥18; stable condition without recent medication changes affecting renal/ocular flow; **Exclusion**: Recent glaucoma surgery (<6 months); significant ocular diseases (e.g., retinal vascular issues, uveitis); acute kidney injury; uncontrolled hypertension, complicated diabetes, or severe cardiovascular disease; non-compliance.

Statistical Analysis

Data were entered into Microsoft Excel and analysed with SPSS v22. Categorical variables used frequencies/proportions, chi-square, or Fisher's exact test (with Yates correction if needed)

Results

Parameter	Group A (Glaucomatous)	Group B (Non-glaucomatous)
Intraocular Pressure (IOP) (mmHg)	22.5 ± 4.1	16.2 ± 2.8
Gonioscopy Findings	Open: 45, Closed: 5	Open: 50, Closed: 0
Optic Nerve Head Assessment (Normal/Abnormal)	Normal: 10, Abnormal: 40	Normal: 50, Abnormal: 0

Table 1: IOP, Gonioscopy findings and Optic nerve head assessment between 2 group

Table 2: **Differences in Orbital Blood Flow Between CKD Patients with and without Glaucoma**

Parameter	Group A (Glaucomatous)	Group B (Non-glaucomatous)	p-value
PSV OA (cm/s)	33.14 ± 3.41	39.61 ± 2.29	<0.001*
RI OA	0.76 ± 0.02	0.74 ± 0.02	0.08
EDV CRA (cm/s)	4.46 ± 0.49	5.12 ± 0.45	0.002*
PSV PCA (cm/s)	12.02 ± 1.15	13.72 ± 1.21	0.002*
RI PCA	0.71 ± 0.03	0.69 ± 0.02	0.05

Table 3: **Differences in Orbital Blood Flow Between CKD Patients with and without Glaucoma**- CKD + glaucoma patients showed significantly lower PSV and EDV in OA, CRA, and PCA, indicating reduced orbital blood flow. RI differences were less significant but trended similarly. and PCA, indicating reduced orbital blood flow. RI differences were less significant but trended similarly.

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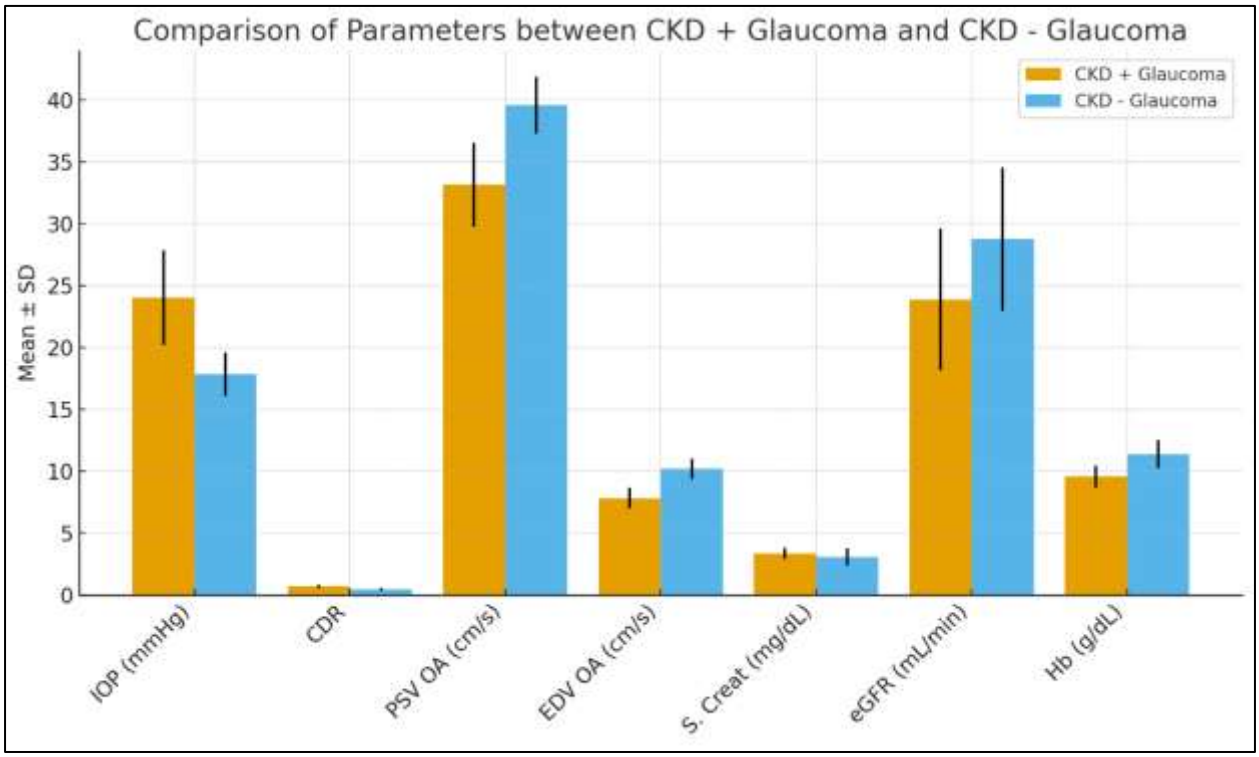

Graph 1: Comparison of parameters between CKD with and without glaucoma: This graph compares IOP, CDR, orbital blood flow (PSV, EDV), kidney markers (S. Creat, eGFR), and hemoglobin in CKD patients with vs. without glaucoma.

DISCUSSION

CKD induces vascular changes that impair ocular blood flow, raising risks for complications like glaucoma. Color Doppler Imaging (CDI) noninvasively detects these hemodynamic shifts by measuring resistivity index (RI), end-diastolic velocity (EDV), and peak systolic velocity (PSV) in arteries such as the ophthalmic (OA), central retinal (CRA), and posterior ciliary (PCA).

Key Hemodynamic Findings

CKD patients, especially with glaucoma, exhibit elevated RI and reduced EDV in OA and CRA, signaling higher vascular resistance and poor perfusion. PSV declines progressively in advanced CKD stages, indicating worsening systolic flow and heightened ischemia risk to the optic nerve and retina.

Underlying Pathophysiology

Endothelial dysfunction from uremic toxins, atherosclerosis, and hypertension disrupts ocular autoregulation, stiffens vessels, and limits nutrient delivery. These factors promote hypoxia, linking CKD to retinopathy, optic neuropathy, and glaucoma—even without elevated IOP.

Clinical Implications

In CKD-glaucoma cases, chronic ischemia accelerates optic nerve damage. CDI enables early screening of perfusion deficits, guiding interventions like blood pressure control to avert vision loss.

Limitations: Small sample size of this reduces statistical power and limits generalizability, Inter-observer variability in CDI measurements - affects consistency.

CONCLUSION

This study emphasizes Color Doppler Imaging's (CDI) essential role in monitoring ocular blood flow in CKD patients. Observed hemodynamic changes—such as heightened vascular resistance and diminished perfusion—signal CKD-related vascular dysfunction and early ocular risks, including retinopathy, ischemic optic neuropathy, and glaucoma.

CDI excels as a screening tool, enabling early identification of high-risk individuals for proactive care. Integrating routine ocular evaluations into CKD management could prevent vision loss and improve quality of life

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