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Serum Uric Acid and Vitamin D Profiles in Glaucoma Patients: A Cross-Sectional Analysis

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KEYWORDS

Glaucoma, Optic nerve, Radioimmunoassay, Uric acid, Vitamin D.

ABSTRACT:

Introduction: Glaucoma, characterized by optic nerve damage linked to inflammation and oxidative stress, is often associated with elevated intraocular pressure (IOP). This study focused on vitamin D, a fat-soluble vitamin known for its anti-inflammatory properties, and uric acid (UA), an antioxidant molecule that scavenges nitrogen radicals and superoxide in plasma, as biomarkers. The primary aim was to evaluate serum levels of vitamin D and UA in glaucoma patients within Indian patients.

Materials and Methods: The study included 78 glaucoma patients and 80 age- and sex-matched controls. Blood samples for biochemical analysis were obtained by venipuncture from the antecubital vein using red-capped vacutainers (6 mL). Serum levels of vitamin D and UA were quantified using radioimmunoassay (RIA) and enzymatic methods, respectively. Statistical analysis utilized Microsoft Excel 2019 and SPSS 19.0. The Shapiro–Wilk W test assessed data normality. Significance levels were set at $p < 0.05$ (significant). Unpaired two-tailed t-tests were used for comparisons.

Results: The analysis indicated that the mean serum vitamin D level in the glaucoma group was 22.25 ± 6.99 ng/mL, compared to 27.72 ± 2.45 ng/mL in the control group. Similarly, the mean UA level was 4.83 ± 1.13 mg/dL in the glaucoma group, compared to 5.98 ± 1.66 mg/dL in the control group. The study found that serum levels of both vitamin D and UA were significantly lower in glaucoma patients compared to healthy controls.

Conclusion: The findings of this highlight the potential clinical value of routinely measuring serum vitamin D and UA in individuals suspected of having glaucoma. The results may assist ophthalmologists in the management and monitoring of glaucoma patients.

Introduction

Glaucoma is a widespread and severe ocular condition, impacting over 70 million individuals globally, with approximately 10% of these patients suffering from bilateral blindness. It is the leading cause of irreversible blindness worldwide. As the global population increases and definitive causative treatments remain limited, the burden of glaucoma continues to escalate. Primary risk

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factors for glaucoma include an elevated cup-to-disc ratio, advanced age, central corneal thickness, family history, and increased intraocular pressure (IOP). Among these, IOP is a modifiable risk factor, and its reduction has been demonstrated to effectively slow the progression of glaucoma. Elevated IOP results from an imbalance in the production and drainage of the aqueous humor within the eye [1-5].

Vitamin D plays a critical role in various biological processes, including immune modulation, cellular proliferation, inflammation reduction, glucose metabolism, and regulation of oxidative stress. The most reliable biomarker for assessing vitamin D status is 25-hydroxy vitamin D [25(OH)D]. Importantly, vitamin D is involved in neuroprotective functions, particularly in the optic nerve, and exerts anti-inflammatory effects by inhibiting the activation of T-helper cells and cytotoxic T-cells, as well as reducing the production of interleukins (IL) -2, -6, -8, and -12 [6-8].

Uric acid (UA), primarily produced in the liver, intestines, and vascular endothelium through purine metabolism, possesses significant antioxidant properties, contributing to over half of the antioxidant capacity of human blood plasma. UA acts as a major antioxidant with metal chelating abilities, scavenges nitrogen radicals and superoxide, and prevents the formation of the strong oxidant peroxynitrite. Consequently, UA is thought to play a protective role in shielding the central nervous system from oxidative damage [8-10].

Despite the recognized importance of vitamin D and UA in neuroprotection and antioxidant defense, there is a paucity of studies examining their levels in glaucoma patients. Therefore, this study aims to evaluate the serum levels of vitamin D and UA in glaucoma patients, specifically within the North Indian population. Additionally, this research seeks to identify potential correlations between these serum levels and IOP, thereby offering valuable insights into the pathophysiology and management of glaucoma.

Material and Methods

This cross-sectional study was conducted in the Department of Biochemistry at the All India Institute of Medical Sciences, Patna, Bihar, India. Participants were aged between 38 and 73 years. The study included 78 glaucoma patients from the outpatient department (OPD) of Ophthalmology, with 80 age- and sex-matched healthy volunteers serving as controls.

Sample Size Calculation:

The sample size was determined using the sample size calculator tool from the website clincalc.com, based on prior research data (mean), with $\alpha = 0.05$, $\beta = 0.05$, and power = 0.95.

Inclusion Criteria:

Patients with any type of glaucoma (excluding glaucoma resulting from trauma) who reported to the OPD of the All India Institute of Medical Sciences, Patna, Bihar, India were included in group I.

Exclusion Criteria:

Patients with self-reported systemic diseases such as acute infectious diseases, hyperuricemia, diabetes, hypertension, autoimmune diseases, metabolic syndrome, kidney disease, and cancer were excluded from the study.

Data Collection:

History was documented for each glaucoma patient, and all relevant information was recorded using a standardized pro forma. Informed consent was secured from all participants.

Sample Collection and Biochemical Analysis:

Blood samples for biochemical analysis were collected via venipuncture from the antecubital vein using red-capped vacutainers, each with a capacity of 6 mL. This method ensures the collection of a sufficient volume of blood for comprehensive biochemical testing. The serum obtained from these blood samples was used to measure vitamin D and uric acid (UA) levels, both of which are critical biomarkers in various physiological and pathological conditions.

Serum vitamin D levels were determined using the radioimmunoassay (RIA) method, a highly sensitive and specific technique that employs radioactively labeled molecules to detect and quantify vitamin D concentrations in the serum. The RIA method is well-regarded for its accuracy and precision in measuring vitamin D, a vital nutrient involved in calcium homeostasis and bone metabolism. The choice of RIA for vitamin D assessment is supported by extensive

Journal of Chemical Health Risks

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validation studies and its widespread use in clinical and research laboratories [11].

Serum uric acid levels were measured using an enzymatic method on an autoanalyzer, a laboratory instrument designed to automate biochemical assays [12]. This enzymatic method involves the use of specific enzymes that catalyze the oxidation of uric acid, producing a measurable product that can be quantified spectrophotometrically. The autoanalyzer enhances the efficiency and reproducibility of the UA measurements, providing rapid and reliable results that are essential for diagnosing and monitoring conditions such as gout and hyperuricemia.

The combination of these advanced analytical techniques—RIA for vitamin D and the enzymatic method for UA—ensures accurate and reliable biochemical profiling of the serum samples, facilitating a comprehensive assessment of the participants' nutritional and metabolic status.

Statistical Analysis:

Statistical analysis was performed using Microsoft Excel 2019. The Shapiro–Wilk W test was used to determine the normal distribution of the data. All patient parameters were presented as mean ± standard deviation (SD). Statistical significance was set at $p < 0.05$, with $p < 0.01$ indicating high significance, and $p > 0.05$ indicating no significance. The unpaired t-test (two-tailed) was employed for statistical comparisons.

Results

Table 1 shows the age distribution of the study participants. The mean age of cases (n=78) was 55.18 years with a standard deviation of 7.71 years, while controls (n=80) had a slightly higher mean age of 57.30 years with a standard deviation of 8.43 years. The age range for both groups was consistent, spanning from 38 to 73 years. The difference in mean ages between cases and controls was not statistically significant, as indicated by a p-value of 0.1. This suggests that there was no significant age difference between the groups, ensuring comparability in terms of age distribution for the study.

Table 1: Age distribution of study participants

Age	**Cases (n=78)**	**Controls (n=80)**	**p-value**
Mean ± SD	55.18 ± 7.71	57.30 ± 8.43	0.1
Range	38–73 years	38–73 years	

Table 2 presents the gender distribution among study participants, showing comparable proportions between cases (n=78) and controls (n=80). Among cases, 53.85% were males (n=42), and 46.15% were females (n=36). Similarly, in the control group, 51.28% were males (n=40), and 48.72% were females (n=38). The p-value for gender distribution between cases and controls was 0.75, indicating no statistically significant difference in gender composition between the two groups. This balanced gender distribution ensures that any observed outcomes in the study are less likely to be influenced by gender bias, thus enhancing the validity of the findings.

Table 2: Gender distribution among study participants

Gender	**Cases (n=78)**		**Controls (n=80)**		**p-value**
	n	**%**	**n**	**%**	
Males	42	53.85	40	51.28	0.75
Females	36	46.15	38	48.72	

Table 3 compares the Vitamin D levels between glaucoma cases (n=78) and controls (n=80), revealing significant differences in the mean levels. The mean Vitamin D level among cases was 22.25 ng/mL with a standard deviation of 6.99 ng/mL, whereas controls had a notably higher mean of 27.72 ng/mL with a standard deviation of 2.45 ng/mL. The range of Vitamin D levels varied from 10.26 ng/mL to 45.60 ng/mL in cases and from 22.91 ng/mL to 37.75 ng/mL in controls. Importantly, the difference in mean Vitamin D levels between cases and controls was statistically significant ($p < 0.05$), suggesting a potential association between lower Vitamin D levels and the presence of glaucoma. These findings underscore the importance of further investigating the role of Vitamin D in glaucoma

Journal of Chemical Health Risks
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pathogenesis and its potential implications for clinical management strategies.

Table 3: Comparison of Vitamin D levels in Glaucoma cases and controls

Variable	Cases (n=78)	Controls (n=80)	p-value
Vitamin D (ng/mL)	22.25 ± 6.99	27.72 ± 2.45	<0.05
Range	10.26–45.60	22.91–37.75	

Table 4 presents the comparison of serum uric acid (UA) levels between glaucoma cases (n=78) and controls (n=80), revealing statistically significant differences. Among glaucoma cases, the mean UA level was 4.83 mg/dL with a standard deviation of 1.13 mg/dL, while controls exhibited a higher mean UA level of 5.98 mg/dL with a standard deviation of 1.66 mg/dL. The range of UA levels varied from 2.76 mg/dL to 8.19 mg/dL in cases and from 3.33 mg/dL to 9.32 mg/dL in controls. The observed difference in mean UA levels between cases and controls was statistically significant ($p < 0.05$), indicating a potential association between elevated UA levels and the presence of glaucoma. Figure 1 visually represents the comparison of Vitamin D and serum uric acid levels between glaucoma cases and controls.

Table 4: Comparison of S. Uric acid levels in Glaucoma cases and controls

Variable	Cases (n=78)	Controls (n=80)	p-value
UA (mg/dL)	4.83 ± 1.13	5.98 ± 1.66	<0.05
Range	2.76–8.19	3.33–9.32	

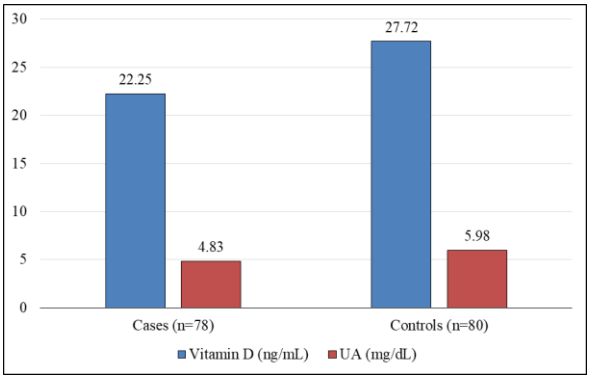

Figure 1: Vitamin D and S. Uric acid levels Glaucoma cases vs controls

Discussion

In this study, we conducted a cross-sectional investigation at a hospital setting to primarily estimate and explore the relationship between serum vitamin D and uric acid (UA) levels among patients diagnosed with glaucoma. Glaucoma, a multifactorial eye disorder influenced by both IOP and systemic conditions, prompts research into modifiable risk factors beyond IOP. Our study aimed at offering insights into underlying disease mechanisms and potential intervention strategies.

The mean age of participants did not differ significantly between groups ($p > 0.05$), and the male-to-female ratio was comparable. Statistical analysis using the Chi-square test indicated no significant difference in sex ratios between groups ($p > 0.05$), consistent with previous studies [6, 13–15].

Our findings from the t-test revealed a statistically significant difference in vitamin D levels between groups ($p < 0.05$). Participants in our study ranged in age from 38 to 73 years, a demographic less prone to vitamin D deficiency compared to older individuals. Factors such as female gender, older age, reduced sun exposure, darker skin type, and inadequate dietary vitamin D intake could have contributed to this deficiency. Skin aging diminishes vitamin D synthesis, further exacerbating deficiencies [16]. A study in South Korea corroborated our findings, linking lower vitamin D levels with primary open-angle glaucoma (POAG) and suggesting a potential risk factor for its development [13].

Vitamin D plays a crucial role in neuronal oxidative stress regulation by activating calcium channels [17]. Research over the past decades has highlighted its

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association with various neurodegenerative disorders [18]. Moreover, vitamin D exerts anti-inflammatory effects, mitigating endothelial dysfunction due to metabolic damage or oxidative stress [19]. Understanding these mechanisms may offer novel insights into glaucoma management, as different pathways may lead to glaucomatous degeneration [20].

Similarly, our t-test analysis demonstrated significantly lower UA levels in glaucoma patients compared to controls ($p < 0.05$). Prior studies on primary angle-closure glaucoma (PACG) reported similar findings, linking lower serum UA levels with disease severity and suggesting a role in oxidative stress-mediated pathogenesis [21–23].

Conclusion

The analysis of the data revealed that the average serum levels of vitamin D and uric acid (UA) were reduced in individuals with glaucoma compared to the control group. Reduced levels of vitamin D and UA may serve as potential risk factors for the onset of glaucoma. The detected association between UA and the progression of glaucoma suggests a possible involvement of oxidative stress in the disease's pathogenesis. Consequently, it is advised that serum vitamin D and UA levels be regularly assessed in individuals suspected of having glaucoma. This study could aid ophthalmologists in the management and follow-up of their glaucoma patients.

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Journal of Chemical Health Risks

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