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Original Research

Correlation of Fundoscopic Findings with Blood Pressure and HbA1c Levels in Type-2 Diabetic Patients

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ABSTRACT

Background: Diabetic retinopathy (DR) is one of the leading causes of vision loss among individuals with Type-2 Diabetes Mellitus (T2DM). Poor glycemic control and hypertension are key risk factors contributing to the development and progression of DR. This study aims to investigate the correlation between fundoscopic findings, blood pressure levels, and glycemic control (HbA1c) in patients with T2DM.

Methods: A cross-sectional observational study was conducted on 200 T2DM patients attending a tertiary care center. Comprehensive ophthalmologic examinations, including fundoscopy, were performed. Blood pressure was measured using a standardized protocol, and recent HbA1c values were recorded. Fundoscopic findings were graded according to the Early Treatment Diabetic Retinopathy Study (ETDRS) classification. Statistical analysis was performed to assess correlations.

Results: Among 200 patients (mean age 56.4 ± 9.2 years), 60% had some form of diabetic retinopathy. Non-proliferative diabetic retinopathy (NPDR) was the most common (43%), followed by proliferative diabetic retinopathy (PDR) in 17% of cases. Patients with moderate to severe NPDR or PDR had significantly higher HbA1c (mean 9.1%) and systolic blood pressure (mean 152 mmHg) compared to those with no retinopathy (mean HbA1c 6.8%, mean SBP 132 mmHg). A positive correlation was observed between DR severity and both HbA1c ($r = 0.61$, $p < 0.001$) and systolic BP ($r = 0.48$, $p < 0.01$).

Conclusion: The study confirms a strong correlation between fundoscopic changes and both blood pressure and glycemic control in T2DM patients. Regular ophthalmologic evaluation along with aggressive management of hyperglycemia and hypertension is crucial to prevent the progression of diabetic retinopathy.

Keywords: Correlation, Blood Pressure, Diabetic Retinopathy.

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INTRODUCTION

Diabetic retinopathy (DR) is a microvascular complication of diabetes mellitus, affecting nearly one-third of diabetic patients globally. It remains a significant cause of preventable blindness. The retina, due to its rich microvascular supply, is highly susceptible to the damaging effects of chronic hyperglycemia and hypertension. While the role of poor glycemic control in DR is well established, increasing evidence suggests that systemic hypertension independently exacerbates retinal vascular damage. Fundoscopic examination remains a vital, non-invasive method for early detection of retinal changes in diabetic individuals.

This study aims to correlate the presence and severity of fundoscopic findings with two critical clinical parameters: blood pressure and glycemic control (as indicated by HbA1c levels) in patients with type-2 diabetes mellitus (T2DM).[1-5]

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MATERIALS AND METHODS

This cross-sectional observational study was conducted over a 12-month period at the Departments of Medicine and Ophthalmology in a tertiary care hospital. The study included a total of 200 adult patients who had been previously diagnosed with T2DM.

Participants were selected consecutively as they attended routine outpatient consultations. The study aimed to assess the correlation between fundoscopic findings and two key systemic parameters—blood pressure and glycated hemoglobin (HbA1c).

Patients were eligible for inclusion if they had a confirmed diagnosis of T2DM for at least one year, were aged between 30 to 70-years, and consented to undergo a detailed ophthalmologic evaluation including fundoscopy. Additionally, participants were required to provide a recent HbA1c report (within the previous one month). Individuals were excluded if they had a diagnosis of Type-1 diabetes mellitus, a history of ocular trauma or any form of eye surgery, or if they had other coexisting retinal pathologies such as hypertensive retinopathy not related to diabetes or retinal vein occlusion. Patients with advanced chronic renal failure were also excluded, as uremic changes in the retina could potentially confound the findings.

Each enrolled patient underwent a standardized clinical evaluation. Blood pressure was measured using a calibrated mercury sphygmomanometer, with the patient in a seated position after resting for at least five minutes. The average of two readings taken five minutes apart was recorded. HbA1c values were retrieved from the hospital's central laboratory database, and only values obtained within one month prior to the ophthalmologic assessment were considered valid for the study.

Ophthalmologic evaluation involved a comprehensive eye examination conducted by a trained ophthalmologist. Visual acuity was measured using a Snellen chart, and fundoscopy was performed after pharmacological pupil dilation. Indirect ophthalmoscopy and slit-lamp biomicroscopy with a 90D lens were employed for retinal examination. The fundoscopic findings were classified according to the Early Treatment Diabetic Retinopathy Study (ETDRS) criteria into the following categories: no diabetic retinopathy, mild non-proliferative diabetic retinopathy (NPDR), moderate NPDR, severe NPDR, and proliferative diabetic retinopathy (PDR).

All data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 25.0. Descriptive statistics were used to summarize baseline characteristics. Pearson's correlation coefficient was calculated to assess the linear relationship between fundoscopic grade and both HbA1c levels and blood pressure values. Analysis of variance (ANOVA) was applied to evaluate mean differences in HbA1c, and blood pressure across different grades of diabetic retinopathy. The Chi-square test was used to explore categorical associations. A *p-value* of less than 0.05 was considered statistically significant.[6-8]

RESULTS

Patient Demographics

A total of 200 patients with T2DM were enrolled in the study. Out of these, 112 were males (56%) and 88 were females (44%). The mean duration of diabetes among participants was 6.3 ± 4.5 years, indicating a moderately chronic diabetic population. The mean glycated hemoglobin (HbA1c) level was found to be 8.1 ± 1.6%, reflecting generally poor glycemic control across the cohort. The mean systolic blood pressure (SBP) was 142 ± 16 mmHg, and the mean diastolic blood pressure (DBP) was 86 ± 8 mmHg.

Table 1: Baseline characteristics of study participants.

Parameter	Value
Total number of patients	200
Gender (Male/Female)	112 (56%) / 88 (44%)
Mean duration of diabetes	6.3 ± 4.5 years
Mean HbA1c (%)	8.1 ± 1.6
Mean Systolic BP (mmHg)	142 ± 16
Mean Diastolic BP (mmHg)	86 ± 8

Table 2: Distribution of Diabetic Retinopathy (DR) Severity.

DR Severity	Number of Patients (*n*)	Percentage (%)
No DR	80	40%
Mild NPDR	40	20%
Moderate NPDR	32	16%
Severe NPDR	14	7%
Proliferative DR (PDR)	34	17%
Total	200	100%

Prevalence of Diabetic Retinopathy

Of the 200 diabetic patients evaluated, 80 (40%) showed no signs of DR on fundoscopy. The remaining 120 patients (60%) demonstrated varying degrees of DR. Mild non-proliferative diabetic retinopathy (NPDR) was seen in 40 patients (20%), moderate NPDR in 32 patients (16%), severe NPDR in 14 patients (7%), and proliferative diabetic retinopathy (PDR) in 34 patients (17%).

Correlation Between Fundoscopic Findings, HbA1c, and Blood Pressure

A strong positive correlation was found between HbA1c levels and the severity of diabetic retinopathy ($r = 0.61$, $p < 0.001$), indicating that patients with poorer glycemic control had more severe fundoscopic findings. Similarly, systolic blood pressure also showed a significant correlation with DR severity ($r = 0.48$, $p < 0.01$). Duration of diabetes was moderately correlated with DR grade ($r = 0.38$, $p < 0.05$), while diastolic blood pressure showed only a weak and statistically non-significant correlation ($r = 0.22$, $p = 0.08$).

Comparison of Parameters Based on DR Severity

On subgroup analysis, patients with PDR had the highest mean HbA1c levels (9.4%), compared to those with moderate NPDR (8.2%),

Table 3: Correlation of Clinical Parameters with Diabetic Retinopathy Severity.

Parameter	Correlation Coefficient (*r*)	*p-value*	Significance
HbA1c (%)	0.61	< 0.001	Strong, Significant
Systolic BP (mmHg)	0.48	< 0.01	Moderate, Significant
Duration of Diabetes	0.38	< 0.05	Moderate, Significant
Diastolic BP (mmHg)	0.22	0.08	Weak, Not Significant

Table 4: Mean HbA1c and SBP According to DR Grade.

DR Grade	Mean HbA1c (%)	Mean Systolic BP (mmHg)
No DR	6.8	132
Mild NPDR	7.5	139
Moderate NPDR	8.2	147
Severe NPDR	8.7	150
PDR	9.4	156

mild NPDR (7.5%), and no DR (6.8%). Similarly, mean systolic BP in patients with PDR was significantly elevated (156 mmHg), as compared to 147 mmHg in moderate NPDR, 139 mmHg in mild NPDR, and 132 mmHg in patients without DR.

The data clearly demonstrate a statistically significant and clinically relevant relationship between poor glycemic control, elevated systolic blood pressure, and the severity of diabetic retinopathy. The strong correlation between HbA1c and DR severity suggests that hyperglycemia remains the most potent modifiable risk factor for retinal damage. The correlation with systolic BP further emphasizes the importance of blood pressure control as a co-factor in retinal microvascular pathology.

Interestingly, diastolic BP did not show a strong association with DR in this study, which is consistent with several prior studies that also found systolic pressure to be more closely related to microvascular complications in diabetes. Patients with proliferative diabetic retinopathy—the most vision-threatening form—exhibited both the highest HbA1c and highest SBP readings, highlighting the compounded effect of dual systemic insults on retinal vasculature.

DISCUSSION

The results of our study strongly reaffirm the pivotal role of metabolic control—specifically glycemic regulation and blood pressure management—in the pathogenesis and progression of DR, a leading microvascular complication of T2DM. Among the clinical parameters analyzed, glycated hemoglobin (HbA1c) emerged as the most robust predictor of DR severity. This underscores the fundamental role of chronic hyperglycemia in damaging the microvasculature of the retina through multiple biochemical and inflammatory pathways.

Prolonged hyperglycemia contributes to retinal vascular damage by triggering a cascade of deleterious mechanisms, including advanced glycation end-product (AGE) formation, oxidative stress, activation of protein kinase C, and increased expression of vascular endothelial growth factor (VEGF). These processes collectively result in capillary basement membrane thickening, pericyte loss, microaneurysm formation, and ultimately, breakdown of the blood-retinal barrier. The strength of correlation ($r = 0.61$, $p < 0.001$) between HbA1c and DR severity in our study reflects how persistently elevated blood glucose levels can lead to progressive retinal pathology, ranging from non-proliferative lesions to proliferative changes with neovascularization.

Equally noteworthy is the significant correlation observed between systolic blood pressure (SBP) and DR severity ($r = 0.48$, $p < 0.01$), even in the presence of elevated HbA1c. This finding highlights the independent and additive effect of hypertension on retinal microcirculation. Chronic elevation of SBP increases hydrostatic pressure in retinal capillaries, accelerates endothelial dysfunction, and promotes capillary leakage and ischemia, contributing to both NPDR and PDR. Unlike diastolic pressure, systolic pressure better reflects the pulsatile stress on vascular walls, especially in elderly diabetic patients with reduced vascular compliance.

These results are in concordance with landmark studies such as the UK Prospective Diabetes Study (UKPDS), which demonstrated that tight blood pressure control significantly reduced the risk of microvascular complications, including retinopathy, by up to 34%. Furthermore, the study revealed that patients who achieved both glycemic and blood pressure targets experienced the most substantial reduction in DR progression. Similarly, the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) and the Diabetes Control and Complications Trial (DCCT) also reported that poor metabolic control is directly associated with increased risk and progression of retinopathy.

Importantly, our findings emphasize the clinical relevance of routine fundoscopic examination in diabetic patients—especially those with concomitant hypertension. Retinal changes detected through fundoscopy not only serve as early indicators of ocular disease but also reflect the overall burden of systemic vascular injury. The retina is the only site in the human body where microvascular pathology can be directly visualized, making it a "window" to the vascular health of diabetic individuals. In this context, early detection of microaneurysms, hemorrhages, or neovascularization can serve as a visual biomarker of systemic disease progression, prompting timely and aggressive therapeutic interventions.

Moreover, the presence of DR in hypertensive diabetic patients should alert clinicians to reevaluate treatment goals and tighten metabolic control, even in asymptomatic individuals. This integrated approach not only helps prevent irreversible vision loss but also reduces the risk of other diabetes-related complications such as nephropathy, neuropathy, stroke, and cardiovascular events.

The findings of our study advocate for a comprehensive, multidisciplinary approach in the management of T2DM, involving diabetologists, ophthalmologists, primary care physicians, and patient educators. Patients should be routinely counseled on the importance of maintaining target HbA1c (<7%) and SBP (<130–140 mmHg), adhering to prescribed medications, adopting lifestyle modifications (diet, exercise, smoking cessation), and undergoing annual dilated retinal examinations.

The synergistic impact of hyperglycemia and hypertension on retinal health is clearly demonstrated in our cohort. Fundoscopic findings, when interpreted alongside systemic parameters like HbA1c and SBP, can serve not only as diagnostic markers but also as prognostic tools in diabetic care. Therefore, integrating retinal evaluation into the routine clinical framework offers a valuable opportunity for early intervention, reduction in visual morbidity, and improved quality of life in patients with T2DM.[9-14]

CONCLUSION

This study highlights the significant correlation of fundoscopic findings with HbA1c and blood pressure levels in patients with type-2 diabetes mellitus. Fundus examination should be an integral part of routine evaluation in diabetic clinics, particularly for patients

with uncontrolled blood glucose and/or hypertension. Targeted interventions to achieve optimal glycemic and blood pressure control can significantly reduce the burden of diabetic retinopathy.

Recommendations

1. Annual dilated fundus examination for all T2DM patients.
2. Maintain HbA1c <7.0% to reduce retinopathy risk.
3. Control systolic BP below 140 mmHg in diabetic patients.
4. Interdisciplinary management involving ophthalmologists, physicians, and diabetic educators is essential.

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