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Role of Glycemic Status, Dyslipidemia, and Kidney Function in the Development of Diabetic Retinopathy: A Tertiary Care Hospital-Based Study

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Abstract: **Background:** Diabetic retinopathy is a major microvascular complication of diabetes mellitus and is a major cause of preventable blindness in diabetic patients around the world. The systemic risk factors that are thought to play an important role in the development and progression of DR include poor glycemic control, dyslipidaemia and renal dysfunction. **Aim:** To investigate the role of glycemic status, dyslipidaemia and renal function in the onset of diabetic retinopathy in diabetic patients of a tertiary care hospital. **Materials and Methodology:** A hospital based cross sectional observational study was conducted over a period of one year in collaboration with the department of Ophthalmology and Biochemistry at a tertiary care hospital. All 80 diagnosed diabetic patients were included in the study. A detailed clinical history and ophthalmological examination as well as biochemical investigations such as fasting blood glucose, HbA1c, lipid profile, serum creatinine, blood urea, estimated glomerular filtration rate (eGFR), and albuminuria were determined. The classification of diabetic retinopathy was done according to the classical grading systems of ophthalmology. Data was analyzed using SPSS Software and p-value <0.05 was considered as statistically significant. **Results:** The age group of 51-60 years old represented the highest number of participants (37.5%) of which 57.5% were males participated in the study. Forty two and a half percent (42.5%) of patients suffered from diabetic retinopathy and mild non-proliferative diabetic retinopathy was the most prevalent stage (20.0%). Poor glycemic control showed significant association with diabetic retinopathy, as 66.7% of patients with HbA1c levels >9% had diabetic retinopathy compared to 16.7% among patients with HbA1c <7% (p <0.001). There was a significant association between elevated triglycerides and LDL cholesterol with diabetic retinopathy (p <0.05). Renal dysfunction was also significantly associated, and the prevalence of diabetic retinopathy in patients with albuminuria and eGFR <60 mL/min were 76.9% and 75.0%, respectively. **Conclusion:** The rates of poor glycemic control, dyslipidaemia and renal dysfunction were independently significant in relation to the development of DR. Periodic eye exams and proper metabolic and renal surveillance may aid in earlier detection of high-risk diabetic patients and prevention of vision-threatening complications.

Keywords: Albuminuria, Diabetes mellitus, Diabetic retinopathy, Dyslipidemia, Glycemic status, HbA1c, Kidney function, Microvascular complications.

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INTRODUCTION

Diabetes mellitus is a major public health problem that leads to prolonged hyperglycemia due to a defect in insulin secretion, insulin action or both. Increasing urbanization, lack of physical activity, obesity and diet changes have significantly contributed to the rising prevalence of diabetes in recent decades. In 2021, there were around 537 million adults with diabetes in the world, a number that will continue to increase rapidly over the coming years [1]. India has one of the highest diabetes burdens among the world and is termed the "diabetes capital" due to the high prevalence of type 2 diabetes mellitus (T2DM) in urban and rural areas, especially in India [2].

Diabetic retinopathy (DR) is a prevalent microvascular diabetic complication and is a leading cause of preventable blindness in working-age adults globally. Progressive retinal microvascular damage due to chronic hyperglycemia causes retinal ischemia, vascular

leakage, macular edema and neovascularization [3]. Patients with diabetes are at increased risk for diabetic retinopathy with prolonged duration of diabetes, poor glycemic control, hypertension, dyslipidemia and nephropathy [4]. Patients with early DR may not experience any symptoms and regular ophthalmic screening is needed to detect early DR and prevent the condition from escalating to a point where visual loss is permanent.

Multiple studies have shown that glycemic status is an important risk factor for the development and progression of DR. An association between fasting blood sugar, increased glycated hemoglobin (HbA1c), and increased retinal microvascular changes and retinopathy severity has been found [5]. Retinal damage is accelerated by persistent hyperglycemia which leads to oxidative stress, endothelial dysfunction, inflammation and breakdown of the blood-retinal barrier [6]. Earlier studies have seen a higher prevalence rate and severity of DR in patients with poor glycemic control as compared to those who have controlled diabetes [7].

Dyslipidaemia is another metabolic derangement which is also common in diabetic patients and has been involved in the pathogenesis of diabetic retinopathy. Additionally, an increase in serum levels of triglyceride, low-density lipoprotein (LDL) cholesterol, and total cholesterol are involved in endothelial dysfunction and formation of hard exudates [8]. In diabetic patients, there is also some evidence that hyperglytriglyceridaemia and impaired lipid metabolism may contribute to an increased risk of macular oedema and progression of retinal lesions [9]. Therefore, the lipid profile assessment could be a useful indicator of diabetic retinopathy risk and severity.

Kidney dysfunction and diabetic nephropathy are also closely associated with diabetic retinopathy because both conditions represent manifestations of systemic diabetic microangiopathy. Microalbuminuria, elevated serum creatinine, and reduced estimated glomerular filtration rate (eGFR) have been reported to correlate with increased prevalence and severity of diabetic retinopathy [10]. Shared pathogenic mechanisms such as chronic hyperglycemia, vascular endothelial damage, oxidative stress, and inflammation contribute to concurrent retinal and renal involvement in diabetic patients [11]. Several studies have demonstrated that diabetic patients with nephropathy are at significantly greater risk of developing vision-threatening retinopathy [12].

Hospital-based studies from India have reported diabetic retinopathy prevalence ranging from approximately 17% to 30% among patients with diabetes mellitus [13]. Singh *et al*. reported an overall prevalence of diabetic retinopathy of 30% in a hospital-based study from North-East India and identified higher HbA1c levels, hypertriglyceridemia, hypertension, and longer duration of diabetes as important associated risk factors [14]. Similarly, studies conducted in tertiary care centres have shown significant association between poor glycemic control, dyslipidemia, nephropathy, and progression of diabetic retinopathy [15]. Diabetic retinopathy is one of the leading causes of preventable blindness among diabetic patients and is strongly associated with poor metabolic control and microvascular complications. The early signs of the disease are not noticeable until later in the disease process, as a result of which the disease is not diagnosed until later stages and consequently visual loss is irreversible. Modifiable systemic risk factors like uncontrolled hyperglycemia, dyslipidaemia and renal dysfunction may be identified at an early stage, risk stratification and early prevention of disease progression. This study is expected to help the Ophthalmology and Biochemistry departments to have better interaction among each other, create awareness for comprehensive metabolic monitoring in Diabetic patients, early ophthalmological referral of high-risk individuals and help develop preventive measures which would help to reduce vision-threatening complications in diabetic patients with better quality of life.

Aim and Objectives

1. The present study aims to evaluate the role of glycemic status, dyslipidemia, and kidney function in the development of diabetic retinopathy among diabetic patients attending a tertiary care hospital.
2. The objectives of the study are to assess the association between glycemic parameters such as fasting blood sugar and HbA1c levels with diabetic retinopathy,
3. Evaluate the relationship between lipid profile abnormalities and the occurrence or severity of diabetic retinopathy
4. Analyze renal function parameters including serum creatinine, blood urea, estimated glomerular filtration rate (eGFR)and albuminuria in relation to retinal changes, and identify systemic metabolic risk factors associated with development of diabetic retinopathy.

MATERIALS AND METHODOLOGY

The present study was conducted as a hospital-based cross-sectional observational study in collaboration between the Departments of Ophthalmology and Biochemistry at a tertiary care hospital (Pt. Deendayal Upadhyay District Hospital attached to Mahatma Vidur Autonomous State Medical College, Bijnor (UP) over a period of one year. A total of 80 diagnosed diabetic patients attending the ophthalmology outpatient department or admitted to the hospital during the study period were included in the study.

Inclusion criteria: Patients diagnosed with type 2 diabetes mellitus aged 30-60 years who were willing to participate in the study were included after obtaining written informed consent.

Exclusion criteria: Patients with gestational diabetes, retinal diseases other than diabetic retinopathy, history of ocular trauma or ocular surgery, chronic inflammatory eye diseases and severely ill patients unable to undergo ophthalmic examination were excluded from the study.

Detailed demographic and clinical information including age, gender, duration of diabetes, treatment history, smoking status, hypertension, and other comorbidities were recorded using a predesigned semi-structured proforma. General physical examination and systemic examination findings were documented.

All enrolled participants underwent complete ophthalmological evaluation including visual acuity assessment, slit lamp examination, fundus examination, and grading of diabetic retinopathy using standard clinical classification systems. Fundus examination was performed after pupillary dilatation using direct and indirect ophthalmoscopy whenever required. Patients were categorized according to the presence and severity of diabetic retinopathy.

Biochemical investigations were carried out in the Biochemistry section of Central Laboratory. Blood samples were collected under aseptic precautions for estimation of fasting blood sugar, postprandial blood sugar, glycated hemoglobin (HbA1c), serum total cholesterol, triglycerides, high-density lipoprotein (HDL), low-density lipoprotein (LDL), serum creatinine, blood urea, and estimated glomerular filtration rate (eGFR). Urine examination for albuminuria or microalbuminuria was also performed wherever indicated.

The data collected were analysed by using statistical package for social sciences (SPSS) software and enter in Microsoft Excel. All the data were presented in descriptive statistics including the mean, standard deviation, number of frequency and percentage. The association between DR vs glycaemic status, lipid profile abnormalities and renal function parameters were assessed by Chi-square test, student t-test and other suitable statistical tests. P values < 0.05 were deemed statistically significant.

The study was approved by the Institutional Ethics Committee before starting the study. The confidentiality and privacy of all participants were respected during this study.

RESULT

The present study included 80 diabetic patients evaluated for the role of glycemic status, dyslipidemia, and kidney function in the development of diabetic retinopathy at a tertiary care hospital. The majority of participants belonged to the age group of 51–60 years (37.5%), followed by 41–50 years (30.0%). Male predominance was observed, with males constituting 57.5% of the study population. Most patients had duration of diabetes between 5–10 years (45.0%), while hypertension was present in 47.5% of participants and smoking history was noted in 22.5% of cases.

Assessment of glycemic status revealed that 47.5% of patients had HbA1c levels between 7–9%, while 22.5% had HbA1c levels greater than 9%, indicating poor glycemic control. Elevated fasting blood sugar levels above 126 mg/dL were observed in 75.0% of participants. Dyslipidemia was commonly observed, with elevated triglycerides present in 55.0% of patients, elevated LDL cholesterol in 50.0%, and elevated total cholesterol in 47.5% of participants.

Kidney function assessment demonstrated elevated serum creatinine levels in 27.5% of patients, while reduced eGFR below 60 mL/min was observed in 20.0% of participants. Albuminuria was present in 32.5% of cases. Diabetic retinopathy was detected in 42.5% of patients, with mild non-proliferative diabetic retinopathy (NPDR) being the most common stage (20.0%), followed by moderate NPDR (12.5%), severe NPDR (6.3%), and proliferative diabetic retinopathy (3.7%).

Significant association was observed between diabetic retinopathy and poor glycemic control. Diabetic retinopathy was present in 66.7% of patients with HbA1c levels greater than 9% compared to only 16.7% among patients with HbA1c levels below 7% ($p < 0.001$). Elevated triglycerides and LDL cholesterol were significantly associated with diabetic retinopathy, affecting 59.1% and 60.0% of patients respectively ($p < 0.05$). Renal dysfunction also showed strong association with diabetic retinopathy,observed in 76.9% of patients with albuminuria and 75.0% of patients with eGFR below 60 mL/min ($p < 0.001$). These findings indicate that poor glycemic control, dyslipidemia, and kidney dysfunction are important systemic risk factors associated with development and progression of diabetic retinopathy.

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 80)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (Years)	31–40	12	15.0
	41–50	24	30.0
	51–60	30	37.5
	>60	14	17.5
Gender	Male	46	57.5
	Female	34	42.5
Duration of Diabetes	<5 years	22	27.5
	5–10 years	36	45.0
	>10 years	22	27.5
Hypertension	Present	38	47.5
	Absent	42	52.5
Smoking History	Present	18	22.5
	Absent	62	77.5

Table 2: Glycemic Status and Lipid Profile among Study Participants (n = 80)

Variable	Category	Frequency (n)	Percentage (%)
HbA1c Levels	<7%	24	30.0
	7–9%	38	47.5
	>9%	18	22.5
Fasting Blood Sugar	<126 mg/dL	20	25.0
	126–200 mg/dL	44	55.0
	>200 mg/dL	16	20.0
Total Cholesterol	Normal	42	52.5
	Elevated	38	47.5
Triglycerides	Normal	36	45.0
	Elevated	44	55.0
LDL Cholesterol	Normal	40	50.0
	Elevated	40	50.0

Table 3: Kidney Function Parameters and Diabetic Retinopathy Status (n = 80)

Variable	Category	Frequency (n)	Percentage (%)
Serum Creatinine	Normal	58	72.5
	Elevated	22	27.5
eGFR	≥90 mL/min	34	42.5
	60–89 mL/min	30	37.5
	<60 mL/min	16	20.0
Albuminuria	Present	26	32.5
	Absent	54	67.5
Diabetic Retinopathy	Present	34	42.5
	Absent	46	57.5
Severity of DR	Mild NPDR	16	20.0
	Moderate NPDR	10	12.5
	Severe NPDR	5	6.3
	PDR	3	3.7

Table 4: Association of Glycemic Status, Dyslipidemia, and Kidney Function with Diabetic Retinopathy (n = 80)

Variable	Category	DR Present n (%)	DR Absent n (%)	p-value
HbA1c Levels	<7%	4 (16.7)	20 (83.3)	<0.001
	7–9%	18 (47.4)	20 (52.6)	
	>9%	12 (66.7)	6 (33.3)	
Triglycerides	Elevated	26 (59.1)	18 (40.9)	0.002
	Normal	8 (22.2)	28 (77.8)	
LDL Cholesterol	Elevated	24 (60.0)	16 (40.0)	0.004
	Normal	10 (25.0)	30 (75.0)	
Albuminuria	Present	20 (76.9)	6 (23.1)	<0.001
	Absent	14 (25.9)	40 (74.1)	
eGFR	<60 mL/min	12 (75.0)	4 (25.0)	0.001
	≥60 mL/min	22 (34.4)	42 (65.6)	

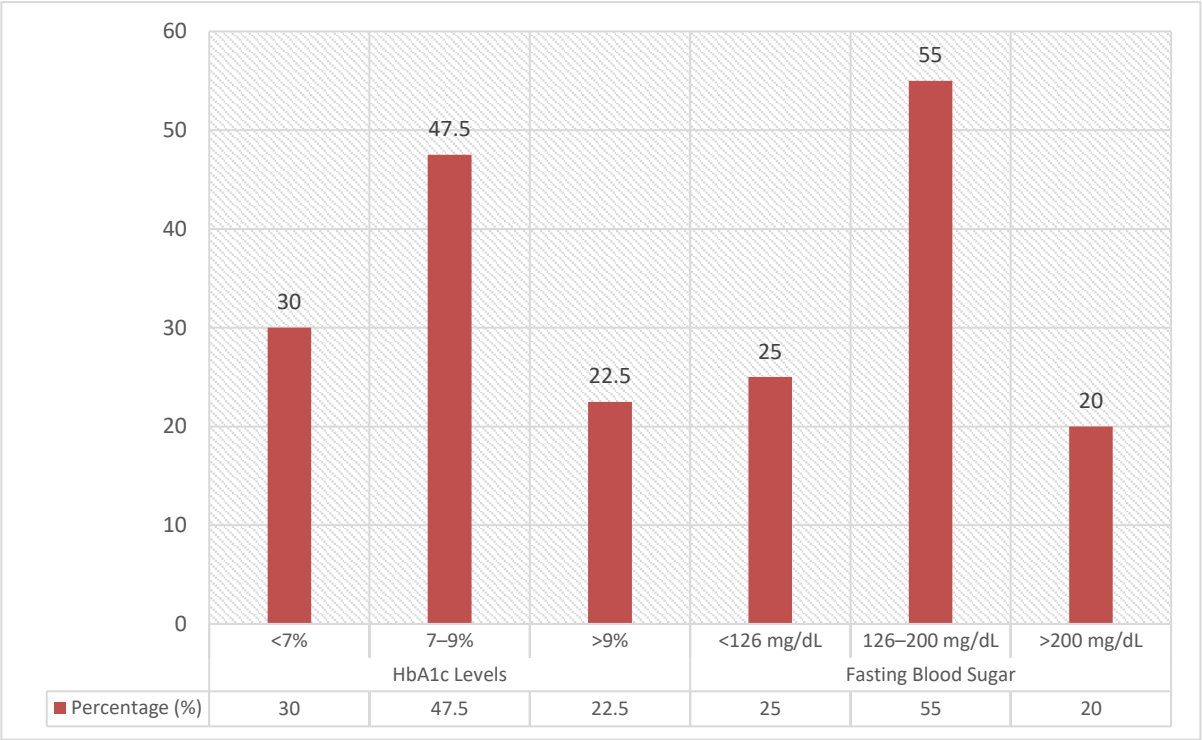

Figure 1: Glycemic Status Among Study Participants

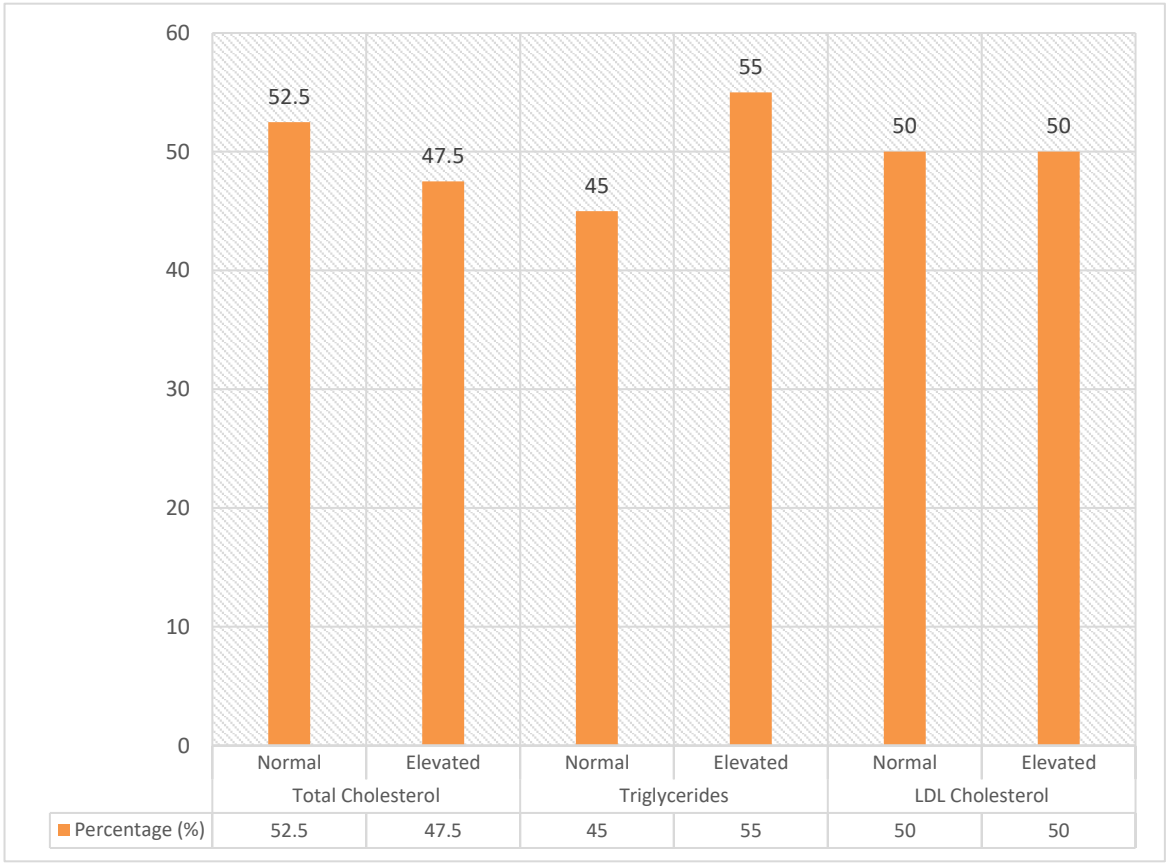

Figure 2: Dyslipidemia Status Among Study Participants

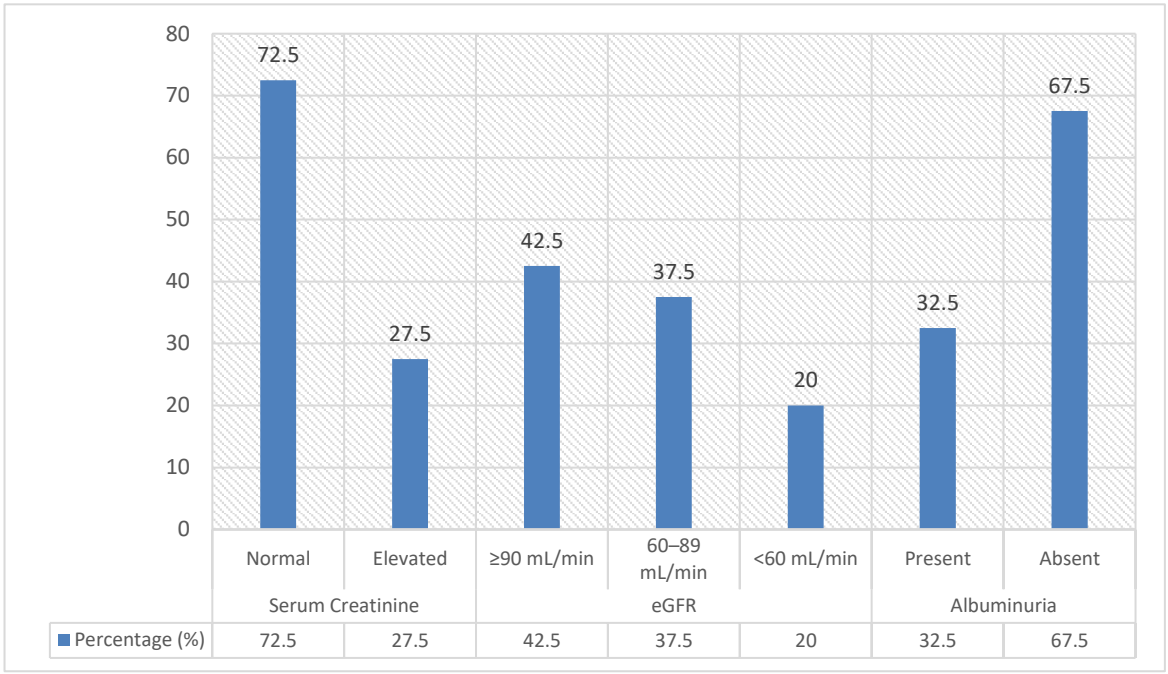

Figure 3: Kidney Function Status Parameters Among Study Participants

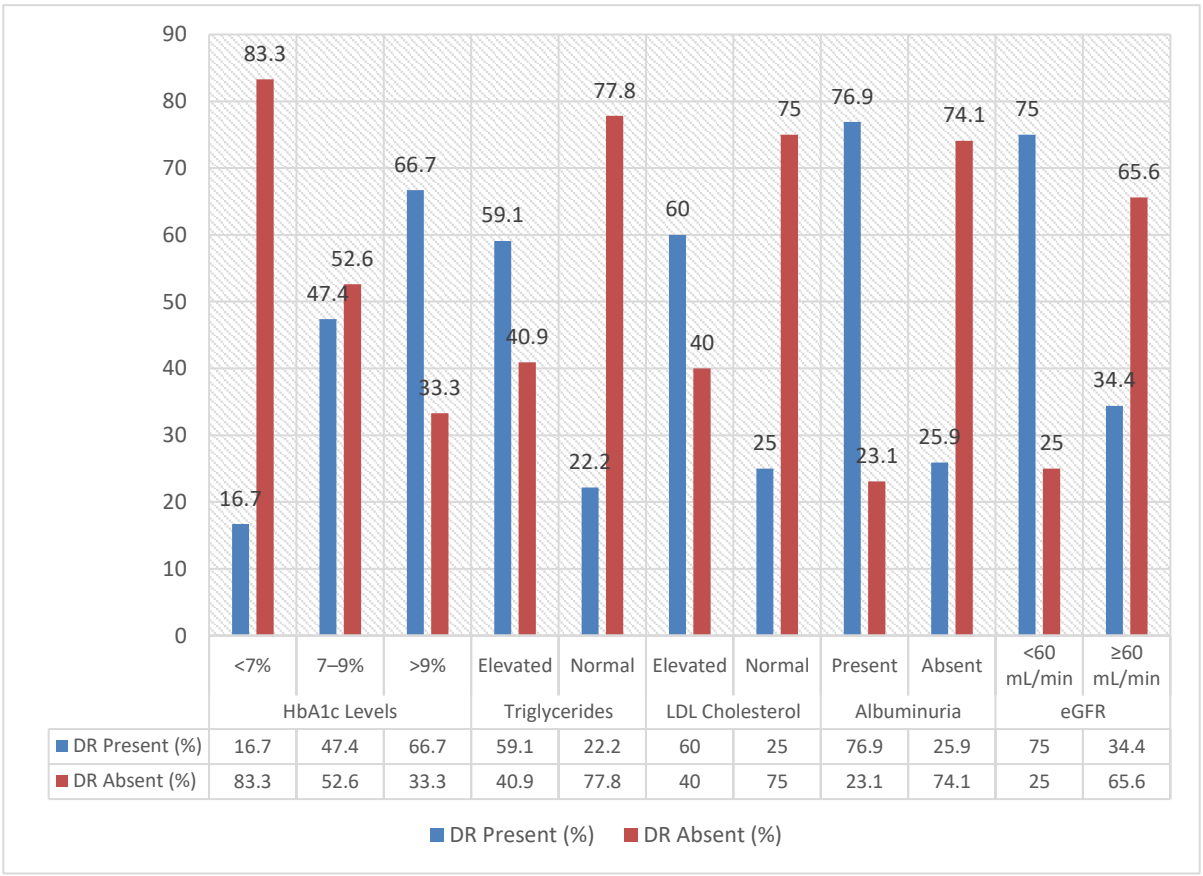

Figure 4: Association of Glycemic Status, Dyslipidemia, and Kidney Function with Diabetic Retinopathy (%)

DISCUSSION

Diabetic retinopathy (DR) is one of the most common microvascular complications of diabetes mellitus and remains a major cause of preventable blindness among diabetic patients. The present study evaluated the association of glycemic status, dyslipidemia, and kidney function with development of diabetic retinopathy among patients attending a tertiary care hospital.

In the present study, the majority of participants belonged to the age group of 51–60 years (37.5%),

followed by 41–50 years (30.0%). Male predominance was observed, with males constituting 57.5% of the study population. Similar findings were reported by Rajeshwari *et al*., who observed maximum prevalence of diabetic retinopathy among patients aged 50–60 years with slightly higher male predominance in their tertiary care hospital-based study [16]. Singh *et al*. also reported increased prevalence of diabetic retinopathy among middle-aged and elderly diabetic patients, particularly among males [9]. Increasing age and longer duration of diabetes may therefore contribute significantly to development of retinal microvascular changes.

The present study demonstrated diabetic retinopathy prevalence of 42.5% among diabetic patients. Mild non-proliferative diabetic retinopathy (NPDR) was the most common stage observed in 20.0% of patients, while proliferative diabetic retinopathy (PDR) was noted in 3.7% of cases. Singh *et al*. reported diabetic retinopathy prevalence of approximately 30% among diabetic patients in North-East India [9], whereas Jayalekshmi*et al*. observed prevalence ranging from 17% to 30% in tertiary care settings [13]. The relatively higher prevalence observed in the present study may be due to inclusion of patients with longer duration of diabetes and poor glycemic control attending a referral tertiary care centre.

Poor glycemic control showed significant association with diabetic retinopathy in the present study. Diabetic retinopathy was present in 66.7% of patients with HbA1c levels greater than 9%, compared to only 16.7% among patients with HbA1c levels below 7% ($p < 0.001$). Rajeshwari *et al*. similarly demonstrated strong positive correlation between higher HbA1c levels and increasing severity of diabetic retinopathy, with statistically significant association observed across all grades of retinopathy [16]. Lokesh *et al*. also reported significantly elevated HbA1c levels among patients with advanced diabetic retinopathy compared to patients without retinal changes [2]. Persistent hyperglycemia causes oxidative stress, endothelial dysfunction, and retinal vascular damage, thereby accelerating progression of diabetic retinopathy.

The present study observed elevated triglyceride levels in 55.0% of participants, and diabetic retinopathy was significantly more common among patients with hypertriglyceridemia (59.1%) compared to those with normal triglyceride levels (22.2%) ($p = 0.002$). Elevated LDL cholesterol was also significantly associated with diabetic retinopathy, affecting 60.0% of patients with raised LDL levels ($p = 0.004$). Rao *et al*. described important pathogenic mechanisms linking dyslipidemia with retinal endothelial dysfunction, inflammation, retinal hard exudate formation, and progression of diabetic retinopathy [17]. Klein *et al*. similarly identified serum lipid abnormalities as important contributors to retinal hard exudates and macular edema among diabetic patients [8]. These findings suggest that dyslipidemia may play an important role in progression and severity of retinal microvascular disease.

Kidney dysfunction showed strong association with diabetic retinopathy in the present study. Albuminuria was present in 32.5% of participants, and diabetic retinopathy was observed in 76.9% of patients with albuminuria compared to 25.9% among patients without albuminuria ($p < 0.001$). Reduced eGFR below 60 mL/min was significantly associated with diabetic retinopathy, affecting 75.0% of such patients ($p = 0.001$). Roche *et al*. similarly demonstrated significant correlation between diabetic nephropathy and diabetic retinopathy among type 2 diabetic patients [18]. Paul *et al*. reported positive correlation between HbA1c levels and renal dysfunction parameters including serum creatinine and blood urea, indicating shared microvascular pathogenic mechanisms between diabetic nephropathy and diabetic retinopathy [19]. These findings support the concept that retinal and renal complications often coexist due to systemic diabetic microangiopathy.

The present study also observed higher prevalence of diabetic retinopathy among patients with longer duration of diabetes and associated hypertension. Singh *et al*. reported hypertension as one of the most common systemic coexisting conditions associated with diabetic retinopathy [9]. Chronic hyperglycemia combined with hypertension may accelerate endothelial injury and retinal ischemic changes, thereby worsening severity of diabetic retinopathy.

Overall, the findings of the present study were comparable with previous national and international studies demonstrating significant association of poor glycemic control, dyslipidemia, and renal dysfunction with diabetic retinopathy. The study emphasizes the importance of regular ophthalmological screening, strict glycemic control, lipid management, and renal monitoring among diabetic patients to reduce progression of retinal complications and prevent vision-threatening outcomes.

CONCLUSION

The present study concluded that diabetic retinopathy is significantly associated with poor glycemic control, dyslipidemia, and renal dysfunction among diabetic patients attending a tertiary care hospital. Higher HbA1c levels, elevated triglycerides, increased LDL cholesterol, albuminuria, and reduced eGFR showed strong correlation with the presence and severity of diabetic retinopathy. Mild non-proliferative diabetic retinopathy was the most commonly observed retinal abnormality, indicating that retinal changes begin early during the course of diabetes and progress with worsening metabolic control. The findings emphasize that diabetic retinopathy is not only an ocular complication but also a marker of systemic

microvascular damage. Early ophthalmological screening combined with regular biochemical and renal monitoring may help in timely identification of high-risk patients and prevention of vision-threatening complications.

Limitations

The study was conducted at a single tertiary care centre with a relatively small sample size of 80 patients, which may limit generalizability of the findings to the broader diabetic population. As the study was cross-sectional in nature, causal relationship between metabolic parameters and progression of diabetic retinopathy could not be established. Longitudinal follow-up of patients was not performed to assess progression of retinal changes over time. Advanced retinal imaging modalities such as optical coherence tomography (OCT) and fluorescein angiography were not routinely performed in all participants. In addition, confounding factors such as dietary habits, medication adherence, and genetic predisposition could not be evaluated comprehensively.

Recommendations

Regular ophthalmological screening should be made mandatory for all diabetic patients, particularly those with poor glycemic control, dyslipidemia, and evidence of renal dysfunction. Strict monitoring and control of HbA1c, lipid profile, and kidney function parameters should be integrated into routine diabetic care to reduce risk of diabetic retinopathy progression. Multidisciplinary management involving Ophthalmology, Biochemistry, and General Medicine departments should be encouraged for comprehensive care of diabetic patients. Awareness programs regarding the importance of retinal examination and metabolic control should be strengthened at both hospital and community levels. Larger multicentric prospective studies with long-term follow-up are recommended to further evaluate the role of systemic metabolic and renal factors in progression of diabetic retinopathy and development of vision-threatening complications.

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