**RESEARCH PAPER**

# Association of Lipid Profile Abnormalities with the Severity of Diabetic Retinopathy

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**ABSTRACT**

**Background:** Diabetic retinopathy (DR) is a leading cause of preventable visual impairment among working-age adults. Although hyperglycemia and hypertension are established risk factors, the contribution of dyslipidemia to the severity of DR remains debated. The aim of the study is to assess the association between lipid profile abnormalities and the severity of DR in patients with Type 2 Diabetes Mellitus (T2DM).

**Methods:** This hospital-based cross-sectional study included 300 adults with type 2 diabetes attending a tertiary care teaching hospital between January and September 2025. DR was graded by dilated fundus examination and photography using the International Clinical Diabetic Retinopathy severity scale. Fasting total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) were measured. Groups were compared by ANOVA, correlations were assessed by Spearman's coefficient, and associations by Chi-square tests, and logistic regression adjusted for age, sex, diabetes duration, HbA1c and hypertension.

**Results:** Evidence of DR was observed in 210 patients (70.0%), and 90 (30.0%) had sight-threatening DR (severe NPDR or PDR). Mean TC, TG and LDL-C rose, and HDL-C fell, progressively across increasing DR severity (all $p < 0.001$): TC 172.4 ± 28.6 mg/dL in No DR vs 229.8 ± 38.9 mg/dL in PDR; LDL-C 96.8 ± 24.2 vs 148.2 ± 33.9 mg/dL; HDL-C 44.6 ± 7.8 vs 34.9 ± 6.2 mg/dL. Dyslipidemia was present in 83.3% overall and in 100% of PDR patients. DR severity correlated positively with LDL-C ($\rho = 0.49$), TC ($\rho = 0.46$) and TG ($\rho = 0.45$) and negatively with HDL-C ($\rho = -0.40$). After adjustment, elevated LDL-C (AOR 5.31; 95% CI 2.31–12.20), elevated TC (AOR 4.52; 95% CI 2.37–8.62), elevated TG (AOR 3.84; 95% CI 2.01–7.33) and low HDL-C (AOR 3.65; 95% CI 1.94–6.86) were independently associated with sight-threatening DR.

**Conclusion:** Dyslipidemia is strongly and independently associated with increasing severity of DR. Routine lipid assessment and optimal lipid control should be integrated into the care of patients with diabetes, alongside glycemic and blood pressure management and regular retinal screening.

**Keywords:** Diabetic retinopathy, Dyslipidemia, Lipid profile, LDL cholesterol, Type 2 diabetes mellitus

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## INTRODUCTION

Diabetes mellitus has reached epidemic proportions worldwide, with an estimated 537 million adults affected in 2021, a figure expected to continue to rise [1]. Diabetic retinopathy (DR), a microvascular complication of diabetes, is among the leading causes of vision loss in working-age adults. A recent meta-analysis estimated that about 103 million adults worldwide had DR in 2020, projected to increase to approximately 160 million by 2045 [2]. Because early DR is often asymptomatic,

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patients frequently present only after sight-threatening complications such as proliferative disease or macular edema have developed.

The duration of diabetes, poor glycemic control and hypertension are the best-established determinants of DR [3]. The pathogenesis of DR, however, involves a complex interplay of chronic hyperglycemia, oxidative stress, inflammation, endothelial dysfunction and breakdown of the blood–retinal barrier [4]. Dyslipidemia may contribute through several mechanisms, including extravasation and retinal deposition of lipoproteins, oxidative modification of LDL particles, and lipid-mediated endothelial injury and inflammation [5]. Elevated serum lipids have long been linked with retinal hard exudates and with severity of retinopathy [6,7] and South Asian population-based data have likewise reported associations between serum lipids and DR [8].

Despite this, epidemiological findings have been inconsistent, with several studies failing to demonstrate a clear relationship between individual lipid fractions and DR. Interventional evidence, however, suggests clinical relevance: lipid-modifying therapy with fenofibrate reduced the need for laser treatment in the FIELD trial [9] and, in combination with simvastatin, slowed retinopathy progression in the ACCORD Eye study [10]. Current standards of care recommend lipid assessment and management as part of comprehensive diabetes care [11].

Data from Indian clinical settings that relate the entire spectrum of DR severity from no retinopathy to proliferative disease to detailed lipid parameters are limited. This study therefore aimed to evaluate the association of lipid profile abnormalities with the severity of DR among patients with Type 2 Diabetes Mellitus (T2DM).

**OBJECTIVES:**

1. To estimate the prevalence of dyslipidemia among patients with type II diabetes mellitus
2. To assess the severity of diabetic retinopathy among patients with type II diabetes mellitus
3. To determine the association between lipid profile parameters and diabetic retinopathy among patients with diabetes mellitus
4. To determine whether there is any difference in the mean values of lipid profile across the five groups of diabetic retinopathies.

**MATERIALS & METHODS**

**Study Design:** A hospital-based, cross-sectional study

**Study Setting:** The study was conducted in the Department of Ophthalmology in a tertiary care teaching hospital, Rajahmundry, Andhra Pradesh, India.

**Study Population:** Adult patients with type II diabetes mellitus

**Study participants:**

**Inclusion Criteria:**
Adult patients with type 2 diabetes mellitus of any duration, aged 30 years and above were included.

**Exclusion Criteria:**
Patients with (i) Current or previous use of lipid-lowering drugs (statins, fibrates, ezetimibe, niacin) within the preceding six months (ii) Secondary diabetes (iii) Hypothyroidism, nephrotic syndrome, chronic liver disease or advanced chronic kidney disease (eGFR <30 mL/min/1.73 m²) (iv) Pregnancy (v) Retinal disease other than DR, prior vitreoretinal surgery, or media opacity precluding fundus evaluation; and (vi) Fasting TG ≥400 mg/dL where direct LDL-C measurement was unavailable.

**Sample size:** Based on the prevalence of dyslipidemia among patients with T2DM from a previous study (p = 60 %), [13] a sample size of 256 was obtained by applying the formula − $n= Z^2 \times p \times q / d^2$, where p is the prevalence, q=1-p, and d is the desired absolute precision taken as 6 %. Including non-response rate of 10 %, the sample size obtained was 284 by sample adjustment through:

$n_{adjusted} = n_{required} / 1 -$ Non-response rate

The adjusted sample of 284 is rounded to the nearest hundreds of 300 (final sample size)

**Sampling Technique**: The study participants were selected by consecutive sampling method.

**Study Period:** The study was conducted over a period of 9 months

**Study tools:** A semi - structured questionnaire was used for the collection of data. It included three distinct sections. The first section consisted of demographic and clinical details. Second section included details of dilated fundus examination. Third section included laboratory investigations. Diabetic Retinopathy was graded in the worse eye using the International Clinical Diabetic Retinopathy Disease Severity Scale [14] as: no DR, mild NPDR, moderate NPDR, severe NPDR, or PDR.

**Data Collection:** A total of 300 participants were enrolled in the study. Each participant was approached; explained about the purpose of the study, and was assured of the anonymity and confidentiality; after taking the informed consent, information was obtained by using semi-structured questionnaire. The assessment instrument for each participant was provided with an identification code.

After taking informed consent from the study participants, demographic and clinical data (age, sex, duration of diabetes, history of hypertension, anthropometry) were recorded. Blood pressure was measured in the seated position, and pupillary dilatation was done; all participants underwent best-corrected visual acuity testing, slit-lamp biomicroscope, and dilated fundus examination by a retina specialist, supplemented by 45° colour fundus photography.

Laboratory investigations: After an overnight fast of 10 – 12 hours, venous blood was collected for plasma glucose, HbA1c (by high-performance liquid chromatography) and a fasting lipid profile. TC, TG and HDL-C were measured by standard enzymatic methods on a fully automated biochemistry analyser with daily internal quality control. LDL-C was calculated using the Fried Ewald equation [15] when TG was <400 mg/dL. Very-low-density lipoprotein cholesterol was not analysed separately. Lipid abnormalities were defined using NCEP ATP III criteria [16], with the lower LDL-C threshold applied to patients with diabetes: elevated TC ≥200 mg/dL; elevated TG ≥150 mg/dL; elevated LDL-C ≥100 mg/dL; and low HDL-C <40 mg/dL in men or <50 mg/dL in women.

**Statistical Analysis:** Data were analyzed with IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation (SD) and categorical variables as frequencies and percentages. Mean values across the five DR severity groups were compared using one-way ANOVA with Tukey's post hoc test, and proportions were compared using the Chi-square test and the chi-square test for linear trend. Spearman's rank correlation was used to relate DR severity grade (coded 0–4) to continuous variables. Binary logistic regression was used to estimate odds ratios (OR) with 95% confidence intervals (CI) for (a) any DR versus no DR and (b) sight-threatening DR (severe NPDR or PDR) versus all other patients. Each lipid abnormality was entered in a separate model adjusted for age, sex, duration of diabetes, HbA1c and hypertension, to avoid collinearity among lipid fractions. Model fit was examined using the Hosmer–Lemeshow test. A two-sided $p < 0.05$ was considered statistically significant.

**Ethical Approval:** Ethical approval will be obtained from the Institutional Ethics Committee of GSL Medical College & General Hospital, Rajahmundry, Andhra Pradesh (approval no. [IEC/IRB Ref No:1619-EC/1619-01/2026]. Before initiating the study, purpose of the study was explained, and informed consent was obtained; anonymity and confidentiality of the information was assured to the study participants.

**OPERATIONAL DEFINITIONS:**

1. Diabetic Retinopathy was defined as per the criteria of
2. Dyslipidemia was defined as the presence of at least one of the lipid abnormalities.
3. Hypertension was defined as a previous diagnosis, use of antihypertensive drugs, or BP ≥140/90 mmHg on two occasions.

**RESULTS**

A total of 300 patients with T2DM were included. The mean age was 56.5 ± 8.9 years, and majority (168, 56.0%) were men. The mean duration of diabetes was 9.5 ± 5.2 years and the mean HbA1c was 8.4 ± 1.6%. Dyslipidemia was observed in 250 patients (83.3%).

**Table 1.** Distribution of study participants by severity of Diabetic Retinopathy using ICDR scale

| Severity of Diabetic Retinopathy (ICDR scale) | Type II DM Patients n= 300 | Percentage (%) |
|---|---|---|
| No diabetic retinopathy | 90 | 30% |
| Mild NPDR | 62 | 20.67% |
| Moderate NPDR | 58 | 19.33% |
| Severe NPDR | 46 | 15.33% |
| Proliferative DR (PDR) | 44 | 14.67% |

ICDR- International Clinical Diabetic Retinopathy; NPDR - Non-Proliferative Diabetic Retinopathy.

Table 1 represents that more than one-fourth (30%) of the study participants had no evidence of Diabetic Retinopathy, 70% had DR, and a notable proportion (15.33%) had severe NPDR.

**Table 2.** Association of Diabetic Retinopathy with Gender and Hypertension

| Variables | No DR (n = 90) n (%) | Mild NPDR (n = 62) n (%) | Moderate NPDR (n = 58) n (%) | Severe NPDR (n = 46) n (%) | PDR (n =44) n (%) | Chi-square statistic | P-value |
|---|---|---|---|---|---|---|---|
| Gender | | | | | | | |
| Male | 49 (54.44%) | 35 (56.45%) | 33 (56.90%) | 26 (56.52%) | 25 (56.82%) | 0.13 | 0.99 |
| Female | 41 (45.56%) | 27 (43.55%) | 25 (43.10%) | 20 (43.48%) | 19 (43.18%) | | |

| Hypertension status | | | | | | | |
|---|---|---|---|---|---|---|---|
| HTN | 33 (36.67%) | 29 (46.77%) | 29 (50%) | 28 (60.87%) | 29 (65.91%) | 13.24 | 0.01 |
| No HTN | 57 (63.33%) | 33 (53.23%) | 29 (50%) | 18 (39.13%) | 15 (34.09%) | | |

Table 2 shows that statistically significant association was observed between Hypertension and severity of Diabetic Retinopathy. P value < 0.05 was considered statistically significant.

**Table 3:** Comparison of Age, Duration of diabetes, HbA1c and BMI among the five study groups of Diabetic Retinopathy

| **Variables** | **Total sample n=300** | **No DR (n=90)** | **Mild NPD (n=62)** | **Moderate NPD (n=58)** | **Severe NPDR (n=46)** | **PDR (n=44)** | **F-value (p-value)** |
|---|---|---|---|---|---|---|---|
| | **Mean ± SD** | | | | | | |
| Age (years) | 56.5 ± 8.9 | 54.2 ± 8.8 | 55.6 ± 8.7 | 56.9 ± 8.9 | 58.7 ± 9.0 | 59.4 ± 8.8 | F = 3.6 (0.006) |
| Duration of diabetes (yrs) | 9.5 ± 5.2 | 6.1 ± 3.4 | 8.4 ± 4.1 | 10.2 ± 4.6 | 12.5 ± 5.0 | 14.1 ± 5.3 | F = 32.8 (<0.001) |
| HbA1c (%) | 8.4 ± 1.6 | 7.4 ± 1.2 | 8.0 ± 1.3 | 8.6 ± 1.4 | 9.2 ± 1.5 | 9.7 ± 1.6 | F = 27.4 (<0.001) |
| Body mass index (kg/m²) | 26.9 ± 3.8 | 26.4 ± 3.6 | 26.8 ± 3.7 | 27.0 ± 3.8 | 27.3 ± 3.9 | 27.5 ± 4.0 | F = 0.82 (0.51) |

Table 3 demonstrates that one-way ANOVA showed a statistically significant difference in mean age among the five groups of Diabetic Retinopathy. The analysis revealed a highly statistically significant difference in the mean duration of diabetes, and HbA1c among the groups ($p < 0.001$); no statistically significant difference in mean body mass index among the five groups ($F = 0.82$, $p = 0.51$), suggesting that BMI was comparable across the groups.

**Figure 1.** Mean (± SD) lipid profile parameters according to the severity of Diabetic Retinopathy (n = 300)

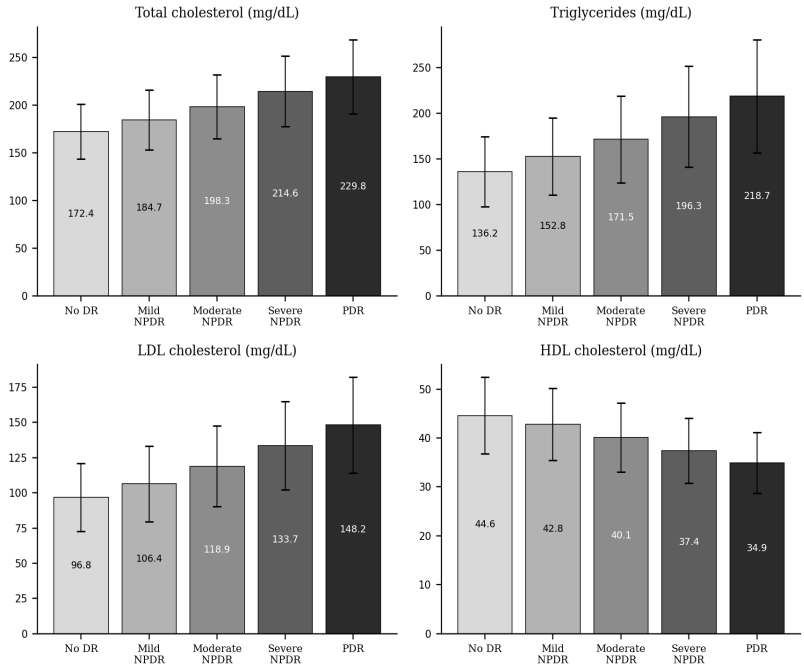


**Table 4.** Comparison of Lipid profile among the five study groups of Diabetic Retinopathy

| Lipid profile (mg/dl) | Total sample (n=300) | No DR (n= 90) | Mild NPDR (n= 62) | Moderate NPDR (n = 58) | Severe NPDR (n= 46) | PDR (n= 44) | F-value (p-value) |
|---|---|---|---|---|---|---|---|
| Total cholesterol | 194.8 ± 38.6 | 172.4 ± 28.6 | 184.7 ± 31.2 | 198.3 ± 33.5 | 214.6 ± 36.8 | 229.8 ± 38.9 | F = 28.4 (<0.001) |
| Triglycerides | 167.8 ± 55.6 | 136.2 ± 38.4 | 152.8 ± 42.1 | 171.5 ± 47.6 | 196.3 ± 55.2 | 218.7 ± 61.8 | F = 28.2 (<0.001) |
| LDL cholesterol | 116.3 ± 33.5 | 96.8 ± 24.2 | 106.4 ± 26.8 | 118.9 ± 28.7 | 133.7 ± 31.4 | 148.2 ± 33.9 | F = 31.0 (<0.001) |
| HDL cholesterol | 40.8 ± 7.9 | 44.6 ± 7.8 | 42.8 ± 7.4 | 40.1 ± 7.1 | 37.4 ± 6.6 | 34.9 ± 6.2 | F = 17.6 (<0.001) |

Table 4 and Figure 1 shows that mean TC, TG and LDL-C increased, and mean HDL-C decreased, stepwise across the five groups of DR ($p < 0.001$ for all). On post hoc analysis, patients with moderate NPDR, severe NPDR and PDR differed significantly from those without DR for all four parameters (Tukey $p < 0.01$), whereas patients with mild NPDR did not differ significantly from those without DR ($p > 0.05$).

**Table 5.** Association of Lipid abnormalities with the severity of Diabetic Retinopathy

| Lipid profile | Total sample n = 300 | No DR (n= 90) | Mild NPDR (n= 62) | Moderate NPDR (n= 58) | Severe NPDR (n= 46) | PDR (n=44) | $\chi^2$ statistic (p-value) |
|---|---|---|---|---|---|---|---|
| Elevated TC (≥200 mg/dL) | 138 (46.0) | 18 (20.0) | 20 (32.3) | 31 (53.4) | 33 (71.7) | 36 (81.8) | 64.78 (<0.001) |
| Elevated TG (≥150 mg/dL) | 177 (59.0) | 31 (34.4) | 33 (53.2) | 38 (65.5) | 36 (78.3) | 39 (88.6) | 46.75 (<0.001) |
| Elevated LDL-C (≥100 mg/dL) | 204 (68.0) | 41 (45.6) | 38 (61.3) | 43 (74.1) | 40 (87.0) | 42 (95.5) | 45.54 (<0.001) |
| Low HDL-C (<40 men / <50 women) | 168 (56.0) | 34 (37.8) | 28 (45.2) | 33 (56.9) | 35 (76.1) | 38 (86.4) | 38.21 (<0.001) |
| Any Dyslipidemia | 250 (83.3) | 58 (64.4) | 50 (80.6) | 53 (91.4) | 45 (97.8) | 44 (100.0) | 38.66 (<0.001) |

Percentages are column percentages within each severity group. TC, total cholesterol; TG, triglycerides; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

Table 5 explains that by application of Chi-square test for categorical variables, highly statistically significant association was observed between Lipid abnormalities and grades of Diabetic Retinopathy ($p$ value $< 0.001$).

Dyslipidemia was present in 250 patients (83.3%). Elevated LDL-C was the commonest abnormality (68.0%), followed by elevated TG (59.0%), low HDL-C (56.0%) and elevated TC (46.0%). The prevalence of each abnormality increased significantly with DR severity (Chi-square for trend $p < 0.001$ for all). Every patient (100%) with PDR had at least one lipid abnormality, compared with 64.4% of those without DR.

**Table 6.** Spearman's correlation of DR severity with lipid profile parameters, duration of DM and HbA1c (n = 300)

| Parameter | Spearman's ρ | p-value |
|---|---|---|
| LDL cholesterol | 0.49 | <0.001 |
| Total cholesterol | 0.46 | <0.001 |
| Triglycerides | 0.45 | <0.001 |
| HDL cholesterol | −0.40 | <0.001 |
| Duration of diabetes | 0.52 | <0.001 |
| HbA1c | 0.48 | <0.001 |

DR severity coded as 0 = no DR, 1 = mild NPDR, 2 = moderate NPDR, 3 = severe NPDR, 4 = PDR.

Correlation of lipid parameters with severity of diabetic retinopathy

Table 6 illustrates that Spearman's rank correlation analysis demonstrated statistically significant associations between DR severity and all four lipid parameters among 300 participants. DR severity showed a moderate positive correlation with LDL-C, TC, and Triglycerides; whereas HDL-C showed a moderate negative correlation with DR severity ($\rho = -0.40$, $p < 0.001$). Duration of diabetes ($\rho = 0.52$) and HbA1c ($\rho = 0.48$) also correlated positively with DR severity.

**Table 7.** Crude and adjusted odds ratios for the association of lipid abnormalities with diabetic retinopathy

| Lipid abnormality | COR (95% CI) | AOR (95% CI) | p-value (adjusted) |
|---|---|---|---|
| **Panel A: Any DR (n = 210) Vs No DR (n = 90)** | | | |
| Elevated TC (≥200 mg/dL) | 5.33 (2.97–9.57) | 3.86 (2.04–7.30) | <0.001 |
| Elevated TG (≥150 mg/dL) | 4.34 (2.57–7.34) | 3.12 (1.76–5.53) | <0.001 |
| Elevated LDL-C (≥100 mg/dL) | 4.15 (2.45–7.02) | 3.47 (1.95–6.17) | <0.001 |
| Low HDL-C | 2.90 (1.74–4.84) | 2.38 (1.38–4.11) | 0.002 |
| **Panel B: Sight-threatening DR (n = 90) Vs Others (n = 210)** | | | |
| Elevated TC (≥200 mg/dL) | 6.71 (3.81–11.84) | 4.52 (2.37–8.62) | <0.001 |
| Elevated TG (≥150 mg/dL) | 5.29 (2.86–9.81) | 3.84 (2.01–7.33) | <0.001 |
| Elevated LDL-C (≥100 mg/dL) | 7.39 (3.40–16.05) | 5.31 (2.31–12.20) | <0.001 |
| Low HDL-C | 5.20 (2.87–9.41) | 3.65 (1.94–6.86) | <0.001 |

COR, crude odds ratio; AOR, adjusted odds ratio (separate model for each lipid abnormality, adjusted for age, sex, duration of diabetes, HbA1c and hypertension); CI, confidence interval. Reference category for each variable: absence of the abnormality. Sight-threatening DR = severe NPDR or PDR. Hosmer–Lemeshow $p > 0.30$ for all models.

Association of lipid abnormalities with DR: logistic regression

Table 7 explains that each lipid abnormality was significantly associated with the presence of DR and, more strongly, with sight-threatening DR. After adjustment for age, sex, duration of diabetes, HbA1c and hypertension, elevated LDL-C showed the strongest association with sight-threatening DR (AOR 5.31; 95% CI 2.31–12.20), followed by elevated TC (AOR 4.52; 95% CI 2.37–8.62), elevated TG (AOR 3.84; 95% CI 2.01–7.33) and low HDL-C (AOR 3.65; 95% CI 1.94–6.86).

## DISCUSSION

In this cross-sectional study of 300 patients with type 2 diabetes mellitus, lipid abnormalities were highly prevalent (83.3%), and showed a graded relationship with the severity of DR. Total cholesterol, Triglycerides and LDL-C rose, and HDL-C fell, with every step up the severity scale, and the relationships persisted after accounting for duration of diabetes, glycaemia control, age, sex and hypertension. The associations were stronger for sight-threatening DR than for DR of any grade, suggesting that dyslipidemia is particularly relevant to progression to advanced disease.

The finding that LDL-C had the strongest association with severe retinopathy is biologically plausible. Retinal capillaries are normally protected by the blood–retinal barrier, but chronic hyperglycemia disrupts this barrier and allows extravasation of lipoproteins into the retinal tissue, where modified LDL particles can promote endothelial dysfunction, inflammation and oxidative injury [4,7]. The retinal deposition of lipid is reflected clinically in hard exudates, which have been linked with higher serum lipid levels in earlier studies [5,6]. The association of low HDL-C with more severe disease is consistent with the loss of the anti-oxidant, anti-inflammatory and endothelial-protective properties of HDL in diabetes. Elevated triglycerides, which reflect insulin resistance and atherogenic remnant lipoproteins, were also independently associated with severity.

Our findings complement observations from South Asian population-based data, which have reported associations between serum lipids and DR [8], although the literature as a whole has been inconsistent. Several factors may explain heterogeneity across studies, including differences in the populations studied, the proportion receiving lipid-lowering therapy, the method of DR grading, and the lipid fractions and cut-offs analyzed. In the present study, patients on lipid-lowering therapy were excluded, which reduced the confounding influence of treatment and may have allowed the underlying relationship to be seen more clearly.

The clinical relevance of lipid control in DR is supported by interventional data. In the FIELD study, fenofibrate reduced the need for laser treatment for DR [9], and in the ACCORD Eye study, intensive glycemic control and fenofibrate added to simvastatin significantly reduced the rate of retinopathy progression compared with the control strategies [10]. Taken together with our findings, these data suggest that lipid assessment should not be viewed solely as a means of cardiovascular risk reduction in people with diabetes, but also as part of a strategy to protect vision. Current standards of care recommend lipid management as part of comprehensive diabetes care [11].

Consistent with the literature, duration of diabetes, HbA1c and hypertension were also significantly associated with DR severity in our cohort, underscoring that dyslipidemia is one component of a multifactorial risk profile. Body mass index did not differ across groups, which indicates that the observed lipid gradient was not simply attributable to adiposity. The high prevalence of dyslipidemia, even among patients without DR (64.4%), highlights a substantial burden of untreated atherogenic risk in this population.

## STRENGTHS AND LIMITATIONS

Strengths of the study include the use of a standardized international DR severity scale with masked grading, the exclusion of patients on lipid-lowering therapy, the analysis of the full severity spectrum rather than a binary outcome, and the reporting of both crude and adjusted estimates. Limitations should be acknowledged. The cross-sectional design precludes conclusions regarding causality or temporal sequence; the lipid abnormalities may precede, follow or merely accompany DR. The study was conducted at a single tertiary center, and referral bias may have increased the proportion with advanced disease. Apolipoproteins, lipoprotein(a) and lipoprotein subfractions, which may be stronger biomarkers than conventional lipids [18], were not measured. Dietary intake, physical activity and renal function indices (other than exclusion of advanced kidney disease) were not assessed in detail, and residual confounding is possible. Finally, macular edema was not analyzed separately.

## CONCLUSION

Lipid profile abnormalities – elevated total cholesterol, triglycerides and LDL cholesterol and low HDL cholesterol – are highly prevalent among patients with type 2 diabetes and are significantly and independently associated with increasing severity of diabetic retinopathy, particularly sight-threatening disease. Routine lipid profiling and optimal lipid control, together with glycemic and blood pressure management, should be integral to diabetes care, and patients with dyslipidemia should be prioritized for regular retinal screening. Prospective studies are needed to confirm these associations and to determine whether targeted lipid modification can prevent progression of retinopathy.

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