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Evaluation of Serum Lipid Profile in Type 2 Diabetes Mellitus Patients and Its Correlation with Diabetic Nephropathy

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ABSTRACT

Background: Dyslipidemia is a hallmark of type 2 diabetes mellitus (T2DM) and is strongly implicated in the progression of diabetic nephropathy (DN). **Objective:** This study aims to evaluate the serum lipid profile in T2DM patients and examine its association with DN, with a focus on identifying specific lipid patterns contributing to renal deterioration. **Methods:** A cross-sectional study was conducted involving 100 T2DM patients aged 35-70 years. Participants were categorized based on glycemic control (HbA1C) and kidney function, assessed via albumin-to-creatinine ratio (ACR) and estimated glomerular filtration rate (eGFR). Biochemical analyses included fasting blood sugar, HbA1C, and serum lipids-total cholesterol, LDL-C, HDL-C, and triglycerides. **Results:** Dyslipidemia was observed in 88% of participants, with elevated triglycerides and low HDL-C being the predominant abnormalities. Patients with DN exhibited significantly higher total cholesterol, LDL-C, and triglycerides and lower HDL-C compared to non-DN counterparts ($p < 0.001$). Dyslipidemia was notably more prevalent in poorly controlled diabetics (HbA1C $\geq$ 7%). **Conclusion:** This study highlights a strong correlation between dyslipidemia and DN, emphasizing its role in renal deterioration. Early identification and management of dyslipidemia may mitigate DN progression and improve outcomes for T2DM patients. Future research should explore the therapeutic impact of lipid-lowering interventions tailored to specific lipid abnormalities.

INTRODUCTION

Diabetes mellitus (DM) is one of the most significant global health challenges, characterized by persistent hyperglycemia resulting from defects in insulin secretion, action, or both. Type 2 diabetes mellitus (T2DM), which accounts for approximately 90% of diabetes cases, arises due to a combination of insulin resistance and β-cell dysfunction. It is closely associated with lifestyle factors such as obesity, sedentary behavior, and poor dietary habits, compounded by genetic predispositions. The global burden of T2DM has seen a sharp rise, with estimates projecting over 700 million affected individuals by 2045, as reported by the International Diabetes Federation (2022). T2DM is a multisystem disorder associated with complications that significantly impair quality of life and impose a substantial burden on healthcare systems. These complications include cardiovascular diseases, neuropathy, retinopathy, and diabetic nephropathy, all of which are accelerated by poorly controlled glycemia and metabolic dysregulation(1-5).

Among the complications of T2DM, diabetic nephropathy (DN) stands out as the most common cause of chronic kidney disease (CKD) and end-stage renal disease (ESRD) globally. DN manifests as a progressive decline in renal function, marked by the onset of albuminuria, reduced glomerular filtration rate (GFR), and hypertension. It is histopathologically characterized by glomerular basement membrane thickening, mesangial expansion, podocyte loss, and interstitial fibrosis. Early detection and management are crucial as DN progresses from microalbuminuria to macroalbuminuria and eventually ESRD, requiring dialysis or kidney transplantation.

Several pathophysiological mechanisms, including chronic hyperglycemia, oxidative stress, and inflammation, drive DN. Hyperglycemia-induced advanced glycation end products (AGEs), activation of the renin-angiotensin-aldosterone system (RAAS), and lipid abnormalities are believed to play significant roles in the progression of renal damage(6-9).

Dyslipidemia is a hallmark of T2DM, characterized by abnormal levels of circulating lipids that exacerbate vascular and renal complications. The typical pattern of diabetic dyslipidemia includes elevated triglycerides, low high-density lipoprotein cholesterol (HDL-C), and small, dense low-density lipoprotein cholesterol (LDL-C) particles, which are more atherogenic. These lipid abnormalities contribute to endothelial dysfunction, systemic inflammation, and oxidative stress, all of which are implicated in the pathogenesis of microvascular complications such as DN. Research has shown that poor glycemic control exacerbates dyslipidemia, increasing the risk of atherosclerotic cardiovascular disease (ASCVD) and renal damage. Importantly, lipid abnormalities in diabetes are not only a consequence of hyperglycemia but also interact with other metabolic disturbances to amplify renal injury through mechanisms such as lipotoxicity and mitochondrial dysfunction(10-13).

The relationship between dyslipidemia and DN is complex and multifactorial. Dyslipidemia has been implicated in the progression of DN through mechanisms including the accumulation of lipids in renal cells, leading to lipotoxicity, inflammation, and fibrosis. Elevated triglycerides and LDL-C can impair podocyte function and increase mesangial expansion, while reduced HDL-C diminishes the kidney's ability to counteract oxidative stress and inflammation. Clinical studies have highlighted that the severity of lipid abnormalities correlates with the progression of DN, with patients exhibiting low HDL-C and high triglycerides often presenting with worse renal outcomes. Consequently, lipid management in T2DM patients is increasingly recognized as an essential component of DN prevention and treatment (14-18).

Despite the well-established link between diabetes and lipid abnormalities, there remains a gap in understanding the specific patterns of dyslipidemia associated with DN in diverse populations. The present study aims to evaluate the serum lipid profile of T2DM patients and its association with DN. By assessing the lipid abnormalities in patients with varying levels of glycemic control and renal impairment, this study seeks to identify specific lipid patterns that may serve as markers or contributors to DN progression. A better understanding of these associations will enable healthcare providers to tailor therapeutic interventions that address both glycemic and lipid abnormalities, thereby mitigating the progression of DN and its complications.

Diabetic nephropathy (DN) is a leading cause of morbidity in type 2 diabetes mellitus (T2DM) and contributes significantly to healthcare costs. While glycemic control remains critical, lipid abnormalities play a crucial role in the progression of DN. Understanding the specific patterns of dyslipidemia associated with DN is essential for improving disease management, particularly in populations with poorly controlled diabetes. This study seeks to address this gap, offering insights that could inform comprehensive management strategies and guide targeted interventions to mitigate DN progression.

METHODS

Study Design and Population:

This cross-sectional study was conducted on a cohort of 100 patients diagnosed with type 2 diabetes mellitus (T2DM) attending a tertiary care hospital. The inclusion criteria comprised patients aged 35–70 years with a confirmed diagnosis of T2DM for more than one year. Patients with type 1 diabetes, acute illnesses, chronic liver disease, or those on lipid-lowering therapy were excluded. Written informed consent was obtained from all participants before enrollment.

Ethical Considerations:

The study was conducted in adherence to the principles outlined in the Declaration of Helsinki and approved by the Institutional Ethics Committee. Participants were fully informed about the study's purpose, procedures, potential risks, and benefits, and written informed consent was obtained. Confidentiality of participant data was ensured by anonymizing all collected information and securely storing it to prevent unauthorized access. Participants were assured of their right to withdraw from the study at any time without consequences to their medical care. The study complied with all national and institutional ethical guidelines governing biomedical research involving human subjects.

Data Collection:

Demographic data, medical history, and duration of diabetes were recorded through structured interviews and clinical records. Anthropometric measurements, including body mass index (BMI), were assessed using standard protocols. Blood pressure measurements were obtained using a calibrated sphygmomanometer, with the average of three readings taken at five-minute intervals.

Biochemical Analysis:

Venous blood samples were collected after an overnight fast of 8-12 hours. Fasting blood sugar (FBS), postprandial blood sugar (PPBS), glycated hemoglobin (HbA1C), and serum lipid profiles were measured using automated biochemical analyzers. Lipid parameters included total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C), which were calculated using the Friedewald formula. Kidney function was assessed by measuring serum creatinine and estimating the glomerular filtration rate (eGFR) using the CKD-EPI equation. Albuminuria was evaluated using the urine albumin-to-creatinine ratio (ACR).

Group Classification:

Patients were categorized based on glycemic control into well-controlled (HbA1C < 7%) and poorly controlled (HbA1C ≥ 7%) groups. Additionally, participants were classified into normoalbuminuria, microalbuminuria, and macroalbuminuria groups based on ACR levels. eGFR values were used to stratify patients into categories reflecting different stages of kidney function.

Statistical Analysis

Data were analyzed using SPSS software version 26. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were expressed as frequencies and percentages. Independent t-tests and one-way ANOVA were used to compare continuous variables between groups, while chi-square tests were employed for categorical variables. Pearson or Spearman correlation analysis was conducted to assess relationships between lipid parameters, glycemic control, and renal function. A p-value of <0.05 was considered statistically significant.

RESULTS

Our study included 100 type 2 diabetes mellitus patients, with 56 males and 44 females. The mean age of the population was 55.2 ± 7.8 years, and the mean duration of diabetes was 5.3 ± 4.6 years. The mean HbA1C was 8.9 ± 2.2, indicating poor glycemic control in most patients. The mean fasting blood sugar (FBS) was 169.6 ± 54.7 mg/dl, and the mean postprandial blood sugar (PPBS) was 278.9 ± 91.3 mg/dl.

The prevalence of dyslipidemia in the study population was 88%. Among males (n=56), 50 patients (89.3%) had dyslipidemia, while among females (n=44), 38 patients (86.4%) had dyslipidemia.

The most common pattern of lipid abnormality was combined dyslipidemia, characterized by high triglycerides and low HDL-C, followed by isolated low HDL-C. The mean lipid parameters were as follows: total cholesterol 178.5 ± 45.3 mg/dl, HDL-C 38.1 ± 11.2 mg/dl, LDL-C 107.2 ± 34.8 mg/dl, and triglycerides 185.3 ± 99.7 mg/dl.

Table 1: Mean Values of Lipid Parameters in Our Study

Lipid Parameter	Mean ± SD
Total Cholesterol (mg/dl)	178.5 ± 45.3
HDL-C (mg/dl)	38.1 ± 11.2
LDL-C (mg/dl)	107.2 ± 34.8
Triglycerides (mg/dl)	185.3 ± 99.7

In our study, dyslipidemia was significantly more prevalent in poorly controlled diabetics (HbA1C > 7) compared to well-controlled diabetics (HbA1C < 7). Of the 12 patients with HbA1C < 7, 5 (41.7%) had dyslipidemia, while 83 (94.3%) out of 88 patients with HbA1C >7 exhibited dyslipidemia. This significant association ($p < 0.001$) underscores the impact of poor glycemic control on lipid abnormalities, highlighting the need for stringent monitoring and management of glycemic levels to reduce the burden of dyslipidemia in diabetes patients.

Table 2: Association of Dyslipidemia with HbA1C

Hba1c Category	Dyslipidemia Present	Dyslipidemia Absent	Total	P-Value
Well-Controlled Diabetes (Hba1c < 7)	5 (41.7%)	7 (58.3%)	12	< 0.001
Poorly Controlled Diabetes (Hba1c > 7)	83 (94.3%)	5 (5.7%)	88	< 0.001
Total	**88**	**12**	**100**	

The distribution of patients across different eGFR levels (>90, 60-90, and <60 ml/min/1.73m²) and stages of albumin-to-creatinine ratio (ACR), namely normo-albuminuria, microalbuminuria, and macroalbuminuria. Among patients with eGFR >90, the majority (42) were in the normo-albuminuria stage, followed by 7 in microalbuminuria and 1 in macroalbuminuria. For eGFR 60-90, 15 patients were in the normo-albuminuria stage, 14 in microalbuminuria, and 5 in macroalbuminuria. In the eGFR <60 category, 1 patient was in normo-albuminuria, 5 in microalbuminuria, and 10 in macroalbuminuria. The distribution highlights a trend where declining eGFR is associated with a higher proportion of patients in advanced stages of ACR, emphasizing the progression of kidney impairment in diabetic patients.

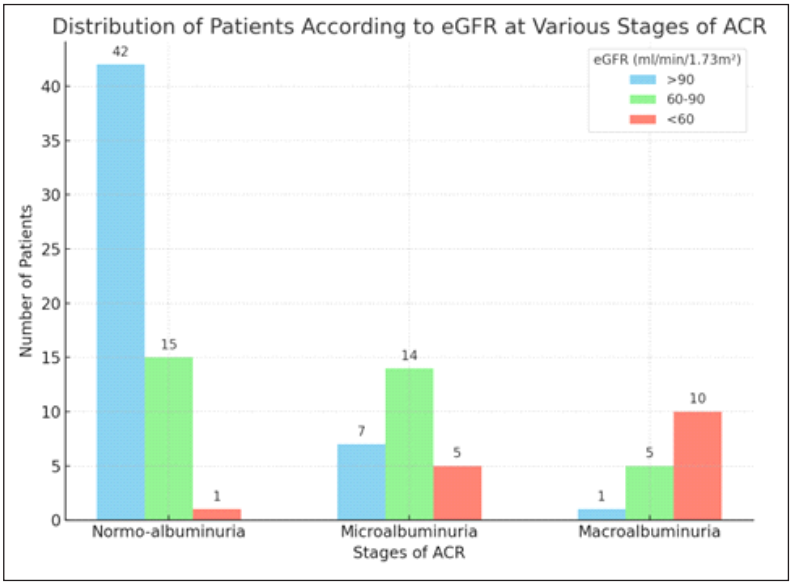

Figure 1: Distribution of Patients According to eGFR at Various Stages of ACR.

The comparison of lipid parameters between patients with diabetic nephropathy (DN) and those without DN reveals notable differences. Patients with DN show higher percentages across all lipid abnormalities, with 84% having low HDL-C, 72% with high LDL-C, 43% with high total cholesterol (TC), and 77% with high triglycerides (TG). In contrast, patients without DN exhibit lower percentages, with 74% having low HDL-C, 18% with high LDL-C, 5% with high TC, and 45% with high TG. The trend indicates that dyslipidemia is more prevalent and severe among patients with DN, underscoring its potential role in the progression of nephropathy in diabetes.

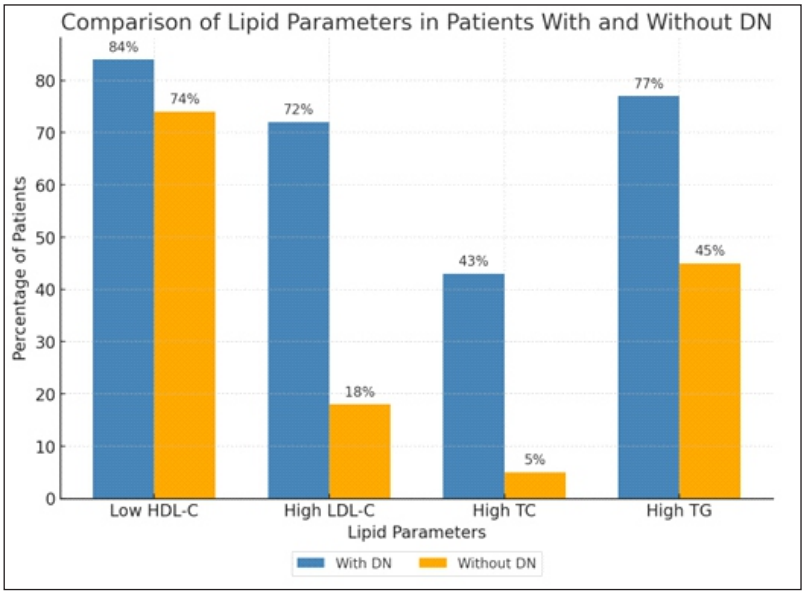

Figure 2: Comparison of Lipid Parameters in Patients With DN and Without DN.

DISCUSSION

Our study highlights significant dyslipidemia in type 2 diabetes mellitus (T2DM) patients, with notable differences in lipid profiles between patients with and without diabetic nephropathy (DN). The findings corroborate existing evidence on the intricate relationship between lipid abnormalities and nephropathy progression in T2DM.

A prominent finding of our study is the prevalence of elevated triglycerides and reduced HDL-C levels, consistent with global and regional studies. For instance, Jayakumari (2020) demonstrated that Indian T2DM patients exhibit a characteristic pattern of high triglycerides and low HDL-C, differing from Western populations, which tend to present higher LDL-C levels. Similarly, Liu et al. (2022) emphasized the independent role of free fatty acids (FFAs), particularly omega-3 polyunsaturated fatty acids (PUFAs) such as DHA, in mitigating albuminuria and progression of DN, suggesting a protective role for these lipids(19,20).

Our study's observation that dyslipidemia correlates with poor glycemic control aligns with Mohan and Vishwanath (2019), who reported that worsening HbA1C is associated with significant elevations in triglycerides and LDL-C, alongside reduced HDL-C. The relationship between lipid abnormalities and glycemic control highlights the synergistic impact of hyperglycemia and dyslipidemia on renal pathology, underscoring the importance of dual the-

rapeutic targeting(21).

The role of specific lipid subfractions, such as phospholipids, was also noted in related literature. Hu et al. (2023) identified serum phosphatidylserine (PS) and phosphatidylcholine (PC) as potential biomarkers for early DN detection, emphasizing their strong association with albuminuria. This finding is particularly relevant, as early identification of lipid disturbances could improve outcomes through timely intervention(22).

Our study adds to the understanding of lipid patterns by documenting the association of combined dyslipidemia-elevated triglycerides and low HDL-C-with advanced stages of DN. This aligns with the findings of Kumar and Mohan (2019), who reported that lipid levels significantly worsen as albuminuria progresses from micro- to macroalbuminuria, highlighting dyslipidemia's role in advancing renal injury.

Interestingly, our data showed a significant gender difference, with males exhibiting a higher prevalence of dyslipidemia, which contrasts with studies in other populations. For example, Liu et al. (2022) found no significant gender-based differences in their cohort from China. This discrepancy may reflect genetic, dietary, or lifestyle factors unique to the studied population, warranting further investigation.

Comparative analysis with other studies also highlights the role of lipid-lowering therapies. Studies have demonstrated that early intervention with statins or fibrates can significantly reduce progression to ESRD in DN patients with severe dyslipidemia. However, our findings underscore the need for individualized therapeutic strategies that address the specific lipid abnormalities observed in different patient subsets.

CONCLUSION

Present study underscores the critical association between dyslipidemia and diabetic nephropathy (DN) in type 2 diabetes mellitus (T2DM) patients. The high prevalence of dyslipidemia, characterized by elevated triglycerides and reduced HDL-C levels, was found to correlate strongly with poor glycemic control and advanced renal impairment. These findings align with existing research, further validating the role of lipid abnormalities in the progression of DN. Moreover, the differential impact of lipid subfractions, such as phospholipids, and their potential as biomarkers for early DN detection highlight the importance of lipidomic profiling in clinical practice.

Our study emphasizes the need for a dual approach targeting both glycemic and lipid control to mitigate DN progression. Given the variation in lipid profiles across populations, individualized management strategies are essential to optimize outcomes. Future research should focus on exploring the efficacy of targeted lipid-lowering therapies and their integration with comprehensive diabetes care. Ultimately, early detection and management of dyslipidemia could significantly reduce the burden of DN and improve the quality of life for T2DM patients.

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