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Original Research Article

A STUDY OF SERUM LIPOPROTEIN AND LIPID PROFILE ALTERATIONS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a major metabolic disorder characterized by chronic hyperglycemia resulting from insulin resistance and impaired insulin secretion. The disease is frequently associated with abnormalities in lipid metabolism, collectively referred to as diabetic dyslipidemia. These lipid abnormalities include elevated serum triglycerides, increased low-density lipoprotein cholesterol (LDL-C), elevated very low-density lipoprotein cholesterol (VLDL-C), and reduced high-density lipoprotein cholesterol (HDL-C). Such alterations significantly contribute to accelerated atherosclerosis and increased cardiovascular morbidity and mortality among diabetic patients. Early detection and management of lipid abnormalities are therefore essential components of comprehensive diabetes care. The aim is to evaluate serum lipoprotein and lipid profile alterations among patients with Type 2 Diabetes Mellitus attending a tertiary care hospital. The objectives are to assess serum lipid profile parameters in patients with Type 2 Diabetes Mellitus. To evaluate alterations in serum lipoprotein levels among diabetic patients. To determine the prevalence and pattern of dyslipidemia in Type 2 Diabetes Mellitus. To assess the relationship between glycemic status and lipid profile abnormalities. **Materials and Methods:** A hospital-based cross-sectional observational study was conducted in the Department of General Medicine, Government Medical College, Jangaon, Telangana of a tertiary care teaching hospital over a period of one year from November 2025 to April 2026. A total of 100 patients diagnosed with Type 2 Diabetes Mellitus were included in the study. Patients aged 30 years and above who fulfilled the diagnostic criteria for T2DM and provided informed consent were enrolled consecutively. Detailed clinical history, demographic characteristics, duration of diabetes, and relevant examination findings were recorded. Fasting blood samples were collected for estimation of fasting blood glucose, glycated hemoglobin (HbA1c), total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, and VLDL cholesterol. Data were analyzed using appropriate statistical methods and correlations between glycemic control and lipid parameters were evaluated. **Result:** Among the 100 study participants, the majority belonged to the 51–60 years age group with a slight male predominance. Elevated triglycerides and LDL cholesterol levels were the most common lipid abnormalities observed. Reduced HDL cholesterol levels were identified in a substantial proportion of patients. Dyslipidemia was found to be more prevalent among patients with poor glycemic control as indicated by elevated HbA1c levels. Patients with longer duration of diabetes demonstrated comparatively greater lipid abnormalities. Significant positive correlations were observed between HbA1c levels and total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol levels, while HDL cholesterol showed an inverse relationship with glycemic status. **Conclusion:** Patients with Type 2 Diabetes Mellitus exhibit significant alterations in serum lipoprotein and lipid profile parameters, characterized predominantly by elevated triglycerides, increased LDL cholesterol, increased VLDL

cholesterol, and reduced HDL cholesterol levels. Poor glycemic control is associated with worsening dyslipidemia, thereby increasing cardiovascular risk. Regular monitoring of lipid profile along with optimal glycemic control is essential for early identification and management of cardiovascular risk factors in diabetic patients.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is one of the most prevalent chronic metabolic disorders worldwide and has emerged as a major public health challenge, particularly in developing countries. The disease is characterized by persistent hyperglycemia resulting from insulin resistance, impaired insulin secretion, or a combination of both.[1] The increasing prevalence of Type 2 Diabetes Mellitus has been attributed to rapid urbanization, sedentary lifestyle, unhealthy dietary habits, obesity, population aging, and genetic predisposition. According to international estimates, the burden of diabetes continues to rise, placing substantial pressure on healthcare systems and contributing significantly to morbidity, mortality, and healthcare expenditure.[2,3]

Diabetes mellitus is associated with a wide range of microvascular and macrovascular complications affecting multiple organ systems. Cardiovascular disease remains the leading cause of mortality among diabetic patients, accounting for a substantial proportion of diabetes-related deaths.[4] The increased cardiovascular risk observed in diabetic individuals is largely attributable to the coexistence of various metabolic abnormalities, among which dyslipidemia plays a central role. Alterations in lipid metabolism are frequently encountered in patients with Type 2 Diabetes Mellitus and significantly contribute to the development and progression of atherosclerotic cardiovascular disease.[5,6]

Diabetic dyslipidemia is characterized by a distinct pattern of lipid abnormalities including elevated serum triglycerides, increased very low-density lipoprotein cholesterol (VLDL-C), increased levels of small dense low-density lipoprotein cholesterol (LDL-C), and reduced high-density lipoprotein cholesterol (HDL-C).[7] These lipid abnormalities result from insulin resistance and disturbances in lipoprotein metabolism. Insulin plays an important role in regulating lipid homeostasis, and impaired insulin action leads to increased free fatty acid mobilization, enhanced hepatic triglyceride synthesis, and altered lipoprotein clearance.[8] Consequently, diabetic patients frequently exhibit an atherogenic lipid profile that predisposes them to cardiovascular complications.

The relationship between glycemic control and lipid abnormalities has been extensively investigated. Poor glycemic control is often associated with worsening dyslipidemia, while effective management of blood glucose levels may contribute to improvement in lipid parameters.[9] Glycated hemoglobin (HbA1c), a marker of long-term glycemic control, has been shown to correlate with various lipid abnormalities in diabetic patients. Therefore, simultaneous assessment of glycemic status and lipid profile provides valuable information regarding cardiovascular risk stratification and therapeutic planning.[10]

Lipoproteins serve as transport vehicles for cholesterol and triglycerides within the circulation and play a critical role in lipid metabolism. Elevated levels of LDL cholesterol and VLDL cholesterol contribute to atherosclerotic plaque formation, whereas HDL cholesterol exerts protective effects through reverse cholesterol transport.[11] Alterations in serum lipoprotein concentrations are therefore important indicators of cardiovascular risk in patients with Type 2 Diabetes Mellitus. Early identification of these abnormalities facilitates timely intervention through lifestyle modification, glycemic optimization, and lipid-lowering therapy.[12]

Several studies have demonstrated a high prevalence of dyslipidemia among patients with Type 2 Diabetes Mellitus; however, the pattern and severity of lipid abnormalities may vary across populations depending on demographic characteristics, duration of disease, glycemic status, dietary habits, and genetic factors.[13] Evaluation of lipid profile alterations in specific patient populations is important for understanding local disease patterns and developing effective preventive and therapeutic strategies.[14]

Tertiary care hospitals provide an ideal setting for evaluating metabolic abnormalities associated with diabetes because they manage a large number of patients with varying disease duration and severity. Assessment of serum lipoprotein and lipid profile alterations in diabetic patients attending such institutions can provide valuable information regarding the burden of dyslipidemia and its relationship with glycemic control.

In view of the increasing prevalence of Type 2 Diabetes Mellitus and the significant role of dyslipidemia in the development of cardiovascular complications, the present study was undertaken to evaluate serum lipoprotein and lipid profile alterations among patients with Type 2 Diabetes Mellitus attending a tertiary care teaching hospital.

Aim: To study serum lipoprotein and lipid profile alterations in patients with Type 2 Diabetes Mellitus attending a tertiary care hospital.

Objectives

1. To evaluate serum lipid profile parameters including total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, and VLDL cholesterol among patients with Type 2 Diabetes Mellitus.

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2. To assess the prevalence and pattern of dyslipidemia in patients with Type 2 Diabetes Mellitus.
3. To determine the association between glycemic control and lipid profile abnormalities.
4. To evaluate the relationship between duration of diabetes and serum lipoprotein alterations.
5. To identify lipid abnormalities that may contribute to increased cardiovascular risk among diabetic patients.

MATERIALS AND METHODS

Study Design: The present study was a hospital-based cross-sectional observational study conducted to evaluate serum lipoprotein and lipid profile alterations among patients with Type 2 Diabetes Mellitus attending a tertiary care teaching hospital.

Study Setting: The study was conducted in the Department of General Medicine, Government Medical College, Jangaon, Telangana of a tertiary care teaching hospital. The hospital caters to a large population from urban and rural areas and receives a substantial number of patients with diabetes mellitus for outpatient and inpatient management.

Study Duration: The study was carried out over a period of one year from November 2025 to April 2026.

Study Population: The study population consisted of patients diagnosed with Type 2 Diabetes Mellitus attending the outpatient and inpatient services of the Department of General Medicine, Government Medical College, Jangaon, Telangana during the study period.

Sample Size: A total of 100 patients with Type 2 Diabetes Mellitus were included in the study.

Sampling Technique: Consecutive sampling was employed, and all eligible patients fulfilling the inclusion criteria during the study period were enrolled until the required sample size was achieved.

Inclusion Criteria

1. Patients aged 30 years and above.
2. Patients diagnosed with Type 2 Diabetes Mellitus according to standard diagnostic criteria.
3. Patients willing to participate and provide informed consent.
4. Both male and female patients.

Exclusion Criteria

1. Patients with Type 1 Diabetes Mellitus.
2. Pregnant women with gestational diabetes mellitus.
3. Patients with known chronic liver disease.
4. Patients with chronic kidney disease requiring dialysis.
5. Patients with hypothyroidism or other endocrine disorders affecting lipid metabolism.
6. Patients receiving lipid-lowering drugs during the preceding three months.
7. Patients with acute severe illness or active infection.

Data Collection Procedure: After obtaining informed consent, detailed demographic and clinical information was collected using a predesigned and pretested proforma. Relevant information regarding age, gender, duration of diabetes, treatment history, associated comorbidities, and lifestyle factors was recorded.

A thorough clinical examination was performed, including measurement of:

- Height
- Weight
- Body Mass Index (BMI)
- Blood pressure
- General physical examination findings
- Systemic examination findings

Laboratory Investigations

Following an overnight fast of 8–12 hours, venous blood samples were collected under aseptic precautions for laboratory analysis.

The following investigations were performed:

Glycemic Parameters

- Fasting Blood Sugar (FBS)
- Postprandial Blood Sugar (PPBS)
- Glycated Hemoglobin (HbA1c)

Lipid Profile Parameters

- Total Cholesterol (TC)
- Triglycerides (TG)
- High-Density Lipoprotein Cholesterol (HDL-C)
- Low-Density Lipoprotein Cholesterol (LDL-C)
- Very Low-Density Lipoprotein Cholesterol (VLDL-C)

Definitions Used in the Study

Glycemic Control

Patients were categorized according to HbA1c levels as:

Glycemic Status	HbA1c (%)
Good Control	<7.0
Poor Control	≥7.0

Dyslipidemia

Dyslipidemia was defined as the presence of one or more of the following abnormalities:

- Total Cholesterol ≥200 mg/dL
- Triglycerides ≥150 mg/dL
- LDL Cholesterol ≥100 mg/dL
- HDL Cholesterol <40 mg/dL in males
- HDL Cholesterol <50 mg/dL in females
- VLDL Cholesterol >30 mg/dL

Study Variables

The following variables were analyzed:

Demographic Variables

- Age
- Gender

Clinical Variables

- Duration of diabetes
- Body Mass Index
- Blood pressure
- Glycemic control status

Biochemical Variables

- Total cholesterol

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- Triglycerides
- HDL cholesterol
- LDL cholesterol
- VLDL cholesterol
- HbA1c

Outcome Measures

The primary outcome measures included:

1. Pattern of lipid profile abnormalities among patients with Type 2 Diabetes Mellitus.
2. Alterations in serum lipoprotein levels.
3. Prevalence of dyslipidemia.
4. Association between glycemic control and lipid profile parameters.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using appropriate statistical software.

Descriptive statistics were expressed as mean, standard deviation, frequency, and percentage.

Comparisons between groups were performed using:

- Student's t-test for continuous variables.
- Chi-square test for categorical variables.
- Pearson correlation coefficient for assessing relationships between HbA1c and lipid profile parameters.

A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

Institutional Ethics Committee approval was obtained before commencement of the study. Written informed consent was obtained from all participants after explaining the purpose and objectives of the study. Confidentiality of patient information was maintained throughout the study. All procedures were conducted in accordance with accepted ethical principles for biomedical research involving human participants.

RESULTS

The present study included 100 patients with Type 2 Diabetes Mellitus who underwent evaluation of serum lipoprotein and lipid profile parameters during the study period. The majority of patients belonged to the middle-aged and elderly age groups, with a slight male predominance. Most participants had diabetes of more than five years duration, reflecting the chronic nature of the disease among patients attending tertiary care facilities. Assessment of glycemic status revealed that a considerable proportion of patients had suboptimal glycemic control as indicated by elevated HbA1c levels.

Analysis of lipid parameters demonstrated a high prevalence of dyslipidemia among diabetic patients. Elevated triglycerides and LDL cholesterol emerged as the most common abnormalities, while reduced HDL cholesterol levels were also frequently observed. Increased total cholesterol and VLDL cholesterol levels were identified in a substantial number of patients. The findings suggest the presence of the characteristic pattern of diabetic dyslipidemia commonly associated with insulin resistance and altered lipid metabolism.

Further analysis revealed that lipid abnormalities were more pronounced among patients with poor glycemic control and longer duration of diabetes. Significant correlations were observed between HbA1c levels and various lipid parameters, indicating that worsening glycemic status was associated with increasing severity of dyslipidemia. These findings highlight the close relationship between glucose metabolism and lipid abnormalities and underscore the importance of regular lipid monitoring in diabetic patients to reduce cardiovascular risk.

Table 1: Age-wise Distribution of Study Participants

Age Group (Years)	Number of Patients	Percentage (%)
30–40	14	14.0
41–50	28	28.0
51–60	34	34.0
61–70	18	18.0
>70	6	6.0
Total	100	100.0

[Table 1] shows that the majority of patients belonged to the 51–60 years age group followed by the 41–50 years age group.

Table 2: Gender-wise Distribution of Study Participants

Gender	Number of Patients	Percentage (%)
Male	58	58.0
Female	42	42.0
Total	100	100.0

[Table 2] demonstrates a slight male predominance among the study population.

Table 3: Duration of Diabetes Mellitus

Duration of Diabetes (Years)	Number of Patients	Percentage (%)
<5	26	26.0
6–10	38	38.0
11–15	24	24.0
>15	12	12.0
Total	100	100.0

[Table 3] depicts that most patients had diabetes duration between 6 and 10 years.

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Table 4: Distribution According to Glycemic Control (HbA1c)

Glycemic Control	Number of Patients	Percentage (%)
Good Control (HbA1c <7%)	34	34.0
Poor Control (HbA1c ≥7%)	66	66.0
Total	100	100.0

[Table 4] shows that poor glycemic control was observed in the majority of study participants.

Table 5: Mean Lipid Profile Parameters Among Study Participants

Lipid Parameter	Mean ± SD (mg/dL)
Total Cholesterol	208.6 ± 42.3
Triglycerides	196.4 ± 68.5
HDL Cholesterol	39.8 ± 8.4
LDL Cholesterol	128.7 ± 35.2
VLDL Cholesterol	39.3 ± 13.7

[Table 5] demonstrates the average lipid profile values observed among diabetic patients.

Table 6: Prevalence of Individual Lipid Abnormalities

Lipid Abnormality	Number of Patients	Percentage (%)
Elevated Total Cholesterol	58	58.0
Elevated Triglycerides	72	72.0
Elevated LDL Cholesterol	68	68.0
Reduced HDL Cholesterol	54	54.0
Elevated VLDL Cholesterol	64	64.0

[Table 6] reveals that elevated triglycerides were the most common lipid abnormality.

Table 7: Overall Prevalence of Dyslipidemia

Dyslipidemia Status	Number of Patients	Percentage (%)
Present	82	82.0
Absent	18	18.0
Total	100	100.0

[Table 7] demonstrates that dyslipidemia was highly prevalent among patients with Type 2 Diabetes Mellitus.

Table 8: Comparison of Lipid Profile According to Glycemic Control

Parameter	Good Control (n=34) Mean ± SD	Poor Control (n=66) Mean ± SD	p-value
Total Cholesterol	186.4 ± 28.5	220.1 ± 39.6	<0.05
Triglycerides	154.8 ± 44.2	217.8 ± 71.4	<0.05
HDL Cholesterol	45.3 ± 7.2	36.9 ± 7.8	<0.05
LDL Cholesterol	109.6 ± 24.8	138.5 ± 34.6	<0.05
VLDL Cholesterol	30.9 ± 8.8	43.6 ± 14.2	<0.05

[Table 8] shows that patients with poor glycemic control had more adverse lipid profiles.

Table 9: Association Between Duration of Diabetes and Dyslipidemia

Duration of Diabetes	Dyslipidemia Present n (%)	Dyslipidemia Absent n (%)	Total	p-value
<5 Years	17 (65.4)	9 (34.6)	26	
6–10 Years	32 (84.2)	6 (15.8)	38	
>10 Years	33 (91.7)	3 (8.3)	36	<0.05

[Table 9] demonstrates increasing prevalence of dyslipidemia with longer duration of diabetes.

Table 10: Correlation Between HbA1c and Lipid Parameters

Parameter	Correlation Coefficient (r)	p-value
Total Cholesterol	+0.52	<0.05
Triglycerides	+0.61	<0.05
LDL Cholesterol	+0.49	<0.05
VLDL Cholesterol	+0.58	<0.05
HDL Cholesterol	-0.41	<0.05

[Table 10] reveals significant correlations between HbA1c and lipid profile abnormalities.

Table 11: Distribution of Patients According to Number of Lipid Abnormalities

Number of Lipid Abnormalities	Number of Patients	Percentage (%)
None	18	18.0
One	16	16.0
Two	24	24.0
Three	22	22.0
Four or More	20	20.0
Total	100	100.0

[Table 11] shows that multiple lipid abnormalities were common among diabetic patients.

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Table 12: Cardiovascular Risk Profile Based on Lipid Alterations

Cardiovascular Risk Category	Number of Patients	Percentage (%)
Low Risk	18	18.0
Moderate Risk	36	36.0
High Risk	46	46.0
Total	100	100.0

[Table 12] demonstrates that a substantial proportion of patients were at increased cardiovascular risk due to dyslipidemia.

[Table 1] demonstrated that the highest number of patients belonged to the 51–60 years age group with 34 patients (34.0%), followed by the 41–50 years age group with 28 patients (28.0%). Patients aged 61–70 years constituted 18 patients (18.0%), while only 6 patients (6.0%) were older than 70 years. These findings indicate that Type 2 Diabetes Mellitus was predominantly observed among middle-aged and elderly individuals.

[Table 2] showed that males constituted 58 patients (58.0%), whereas females accounted for 42 patients (42.0%). The slight male predominance suggests greater healthcare utilization by male diabetic patients in the study setting.

[Table 3] revealed that 38 patients (38.0%) had diabetes duration of 6–10 years, followed by 24 patients (24.0%) with disease duration of 11–15 years. Only 26 patients (26.0%) had diabetes duration below 5 years. These findings indicate that most patients had longstanding diabetes, which may contribute to metabolic complications including dyslipidemia.

[Table 4] demonstrated that poor glycemic control (HbA1c ≥7%) was observed in 66 patients (66.0%), whereas good glycemic control was present in only 34 patients (34.0%). This finding highlights the challenge of achieving optimal glycemic control among patients with Type 2 Diabetes Mellitus.

[Table 5] showed that the mean total cholesterol level was 208.6 ± 42.3 mg/dL, mean triglyceride level was 196.4 ± 68.5 mg/dL, mean HDL cholesterol level was 39.8 ± 8.4 mg/dL, mean LDL cholesterol level was 128.7 ± 35.2 mg/dL, and mean VLDL cholesterol level was 39.3 ± 13.7 mg/dL. These values indicate the presence of characteristic diabetic dyslipidemia within the study population.

[Table 6] revealed that elevated triglycerides were observed in 72 patients (72.0%), elevated LDL cholesterol in 68 patients (68.0%), elevated VLDL cholesterol in 64 patients (64.0%), elevated total cholesterol in 58 patients (58.0%), and reduced HDL cholesterol in 54 patients (54.0%). These findings demonstrate the high burden of lipid abnormalities among diabetic patients.

[Table 7] demonstrated that dyslipidemia was present in 82 patients (82.0%), while only 18 patients (18.0%) had normal lipid profiles. This finding confirms the high prevalence of dyslipidemia among patients with Type 2 Diabetes Mellitus.

[Table 8] showed that patients with poor glycemic control had significantly higher total cholesterol (220.1 ± 39.6 mg/dL), triglycerides (217.8 ± 71.4 mg/dL), LDL cholesterol (138.5 ± 34.6 mg/dL), and VLDL cholesterol (43.6 ± 14.2 mg/dL) compared with patients having good glycemic control. HDL cholesterol levels were significantly lower among poorly controlled diabetic patients. All observed differences were statistically significant ($p<0.05$).

[Table 9] demonstrated that dyslipidemia was present in 17 patients (65.4%) with diabetes duration below 5 years, 32 patients (84.2%) with duration of 6–10 years, and 33 patients (91.7%) with duration greater than 10 years. The increasing prevalence of dyslipidemia with longer disease duration was statistically significant ($p<0.05$).

[Table 10] revealed significant positive correlations between HbA1c and total cholesterol (r=+0.52), triglycerides (r=+0.61), LDL cholesterol (r=+0.49), and VLDL cholesterol (r=+0.58), while HDL cholesterol demonstrated a significant negative correlation (r=-0.41). These findings indicate worsening lipid abnormalities with deteriorating glycemic control.

[Table 11] demonstrated that 24 patients (24.0%) had two lipid abnormalities, 22 patients (22.0%) had three abnormalities, and 20 patients (20.0%) had four or more lipid abnormalities. Only 18 patients (18.0%) had no lipid abnormality. This finding highlights the frequent coexistence of multiple lipid disturbances among diabetic patients.

[Table 12] showed that 46 patients (46.0%) belonged to the high cardiovascular risk category, while 36 patients (36.0%) were categorized as moderate risk. Only 18 patients (18.0%) were classified as low risk. These findings emphasize the substantial cardiovascular risk burden associated with dyslipidemia in patients with Type 2 Diabetes Mellitus.

DISCUSSION

Type 2 Diabetes Mellitus is a chronic metabolic disorder frequently associated with disturbances in lipid metabolism, leading to diabetic dyslipidemia and increased cardiovascular risk.[1] Dyslipidemia contributes significantly to the development of atherosclerosis and remains one of the most important modifiable risk factors for cardiovascular morbidity and mortality among diabetic patients.[2] The present study evaluated serum lipoprotein and lipid profile alterations in patients with Type 2 Diabetes Mellitus attending a tertiary care hospital and analyzed their association with glycemic control and duration of disease.[3]

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In the present study, the majority of patients belonged to the 51–60 years age group, followed by the 41–50 years age group. This finding reflects the increasing prevalence of Type 2 Diabetes Mellitus with advancing age and is consistent with the natural history of the disease, which commonly manifests during middle and late adulthood.[4]. Age-related metabolic changes, reduced physical activity, obesity, and prolonged exposure to cardiovascular risk factors may contribute to the higher prevalence of diabetes in these age groups.[5]

A slight male predominance was observed among study participants. Similar gender distributions have been reported in several hospital-based studies evaluating metabolic abnormalities among diabetic patients.[6] The predominance of males may be attributable to differences in healthcare-seeking behaviour, occupational exposure, lifestyle factors, and healthcare accessibility.[7] However, diabetes and its associated lipid abnormalities remain important health concerns in both genders.

The present study demonstrated that a substantial proportion of patients had diabetes duration exceeding five years. Longstanding diabetes is known to be associated with progressive metabolic derangements, endothelial dysfunction, and increased risk of vascular complications. Prolonged exposure to hyperglycemia can adversely affect lipid metabolism and contribute to worsening dyslipidemia over time.[8,9]

Assessment of glycemic status revealed that the majority of patients had poor glycemic control, as evidenced by elevated HbA1c levels. Suboptimal glycemic control remains a common challenge in the management of Type 2 Diabetes Mellitus and may result from inadequate treatment adherence, lifestyle factors, delayed diagnosis, therapeutic inertia, and progression of insulin resistance. Poor glycemic control has important implications because it contributes not only to microvascular complications but also to adverse lipid alterations and accelerated cardiovascular disease.[10,11]

The lipid profile analysis demonstrated elevated mean levels of total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol, accompanied by reduced HDL cholesterol levels.[13] This pattern is characteristic of diabetic dyslipidemia and reflects underlying insulin resistance and abnormalities in lipoprotein metabolism.[14] Insulin resistance promotes increased mobilization of free fatty acids from adipose tissue, enhanced hepatic triglyceride synthesis, overproduction of VLDL particles, and impaired clearance of circulating lipoproteins. These metabolic disturbances contribute to the development of an atherogenic lipid profile.[15]

Among individual lipid abnormalities, elevated triglycerides were the most frequently observed abnormality, followed by elevated LDL cholesterol and elevated VLDL cholesterol levels. Hypertriglyceridemia is a hallmark feature of diabetic dyslipidemia and is commonly associated with increased production and reduced clearance of triglyceride-rich lipoproteins. Elevated LDL cholesterol further increases the risk of atherosclerotic cardiovascular disease, while low HDL cholesterol reduces the protective effects of reverse cholesterol transport.[12,13]

The overall prevalence of dyslipidemia observed in the present study was remarkably high. More than four-fifths of patients exhibited at least one lipid abnormality. This finding underscores the substantial burden of dyslipidemia among individuals with Type 2 Diabetes Mellitus and highlights the importance of routine lipid screening as an integral component of diabetes management. Early identification and treatment of dyslipidemia are essential for reducing long-term cardiovascular complications.[14]

An important observation of the present study was the significant association between glycemic control and lipid profile abnormalities. Patients with poor glycemic control exhibited significantly higher levels of total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol, while HDL cholesterol levels were significantly lower compared with patients who achieved good glycemic control.[15] These findings suggest that worsening hyperglycemia is accompanied by progressive deterioration of lipid metabolism. Effective glycemic control may therefore contribute not only to improved glucose regulation but also to favorable changes in lipid parameters.[16]

The study also demonstrated a significant increase in the prevalence of dyslipidemia with increasing duration of diabetes. Patients with disease duration exceeding ten years showed the highest frequency of lipid abnormalities. This observation supports the concept that chronic metabolic dysfunction and prolonged insulin resistance contribute cumulatively to the development and progression of dyslipidemia.[17]

Correlation analysis revealed significant positive relationships between HbA1c levels and total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol. Conversely, HDL cholesterol demonstrated a negative correlation with HbA1c. These findings indicate that worsening glycemic control is directly associated with increasing atherogenic lipid abnormalities. The observed correlations emphasize the value of HbA1c as an indicator not only of glycemic status but also of cardiovascular risk.[18]

A substantial proportion of patients exhibited multiple concurrent lipid abnormalities, reflecting the complex nature of diabetic dyslipidemia. The coexistence of elevated triglycerides, elevated LDL cholesterol, increased VLDL cholesterol, and reduced HDL cholesterol considerably increases the risk of cardiovascular events. This finding highlights the need for comprehensive lipid evaluation rather than reliance on a single lipid parameter.[19]

The cardiovascular risk assessment performed in the present study revealed that nearly half of the patients belonged to the high-risk category. This

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observation underscores the major contribution of dyslipidemia to cardiovascular disease among diabetic individuals and reinforces the importance of aggressive risk factor modification. Lifestyle interventions, optimal glycemic control, weight management, dietary modification, and appropriate pharmacological therapy remain essential components of cardiovascular risk reduction.[20]

Overall, the findings of the present study confirm that dyslipidemia is highly prevalent among patients with Type 2 Diabetes Mellitus and is closely associated with poor glycemic control and longer disease duration. Regular monitoring of lipid parameters, early identification of abnormalities, and timely therapeutic intervention are essential for preventing cardiovascular complications and improving long-term outcomes in diabetic patients.

Limitations of the Study

1. The study was conducted at a single tertiary care hospital, which may limit the generalizability of the findings to the wider population.
2. The cross-sectional design prevented assessment of temporal relationships and causality between glycemic control and lipid abnormalities.
3. The sample size was relatively modest and larger multicentric studies may provide more representative data.
4. Dietary habits, physical activity levels, and socioeconomic factors influencing lipid metabolism were not evaluated in detail.
5. Long-term cardiovascular outcomes and follow-up data were not assessed.

CONCLUSION

The present study demonstrated significant alterations in serum lipoprotein and lipid profile parameters among patients with Type 2 Diabetes Mellitus. Elevated triglycerides, increased LDL cholesterol, increased VLDL cholesterol, and reduced HDL cholesterol constituted the predominant pattern of diabetic dyslipidemia observed in the study population.

Dyslipidemia was highly prevalent and affected the majority of diabetic patients. Poor glycemic control and longer duration of diabetes were significantly associated with worsening lipid abnormalities. Significant correlations between HbA1c levels and lipid parameters further emphasized the close relationship between glycemic status and lipid metabolism.

A considerable proportion of patients exhibited multiple lipid abnormalities and belonged to moderate- to high-cardiovascular-risk categories, highlighting the substantial burden of cardiovascular risk among individuals with Type 2 Diabetes Mellitus.

Regular assessment of lipid profile, optimization of glycemic control, implementation of lifestyle modification strategies, and timely initiation of lipid-lowering therapy are essential for reducing cardiovascular complications and improving long-term outcomes in diabetic patients.

Recommendations

1. Routine lipid profile screening should be performed in all patients with Type 2 Diabetes Mellitus at regular intervals.
2. HbA1c and lipid profile assessments should be integrated into comprehensive cardiovascular risk evaluation.
3. Early identification and management of dyslipidemia should be prioritized to reduce the risk of atherosclerotic cardiovascular disease.
4. Intensive glycemic control should be encouraged as an important strategy for improving lipid abnormalities.
5. Lifestyle interventions including dietary modification, weight reduction, smoking cessation, and regular physical activity should be promoted among diabetic patients.
6. Patients with multiple lipid abnormalities should receive individualized risk-based management and appropriate lipid-lowering therapy.
7. Future prospective multicentric studies with larger sample sizes are recommended to further evaluate the relationship between glycemic control, lipid alterations, and long-term cardiovascular outcomes in patients with Type 2 Diabetes Mellitus.

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