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DISTRIBUTION & DETERMINANTS OF LIPID DISORDERS IN PATIENTS UNDERGOING HEMODIALYSIS

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ABSTRACT

Introduction: Patients with end-stage renal disease (ESRD) on maintenance hemodialysis (MHD) exhibit a distinct lipid profile marked by hypertriglyceridemia, low HDL, and paradoxically low or normal cholesterol, influenced by malnutrition and inflammation. Hemodialysis further alters lipid and protein levels, affecting risk assessment. Given the high cardiovascular burden, this study evaluates lipid abnormalities, their determinants, and related cardiovascular findings.

Aim and Objective: To evaluate the distribution and determinants of lipid abnormalities in patients undergoing maintenance hemodialysis (MHD), examine the paradoxical impact of low lipid levels, compare pre- and post-dialysis lipid profiles and serum albumin, and assess cardiovascular involvement using ECG and 2D echocardiography.

Materials and Methods: A serial cross-sectional study was conducted on 150 adult patients with end-stage renal disease (ESRD) receiving regular MHD at Sree Balaji Medical College & Hospital over a period of 10 months. Biochemical parameters, including lipid profile and serum albumin, were measured before and after dialysis. Cardiovascular abnormalities were evaluated using ECG and 2D echocardiography.

Results: The mean age of participants was 54.98±18.15 years, with a male predominance (67%). Hypertension (80%) and diabetes (50%) were the most common comorbidities. Hypertriglyceridemia was the most frequent lipid abnormality (79%), followed by low HDL levels (48%) and hypolipidemia (22%). Post-dialysis analysis showed significant reductions in total cholesterol (176.49 to 165.10 mg/dL, $p=0.004$), LDL (95.66 to 86.20 mg/dL, $p=0.008$), and VLDL (40.34 to 36.80 mg/dL, $p<0.001$). Serum albumin levels also declined significantly after dialysis (3.00 to 2.80 g/dL, $p<0.001$). Cardiovascular abnormalities were common, with ECG changes observed in 50% of patients, diastolic dysfunction in 33%, and cardiovascular events in 33%.

Conclusion: Hemodialysis patients show a distinct dyslipidemia pattern with high triglycerides, low HDL, and paradoxically low cholesterol. Dialysis reduces atherogenic lipids, but the high cardiovascular burden necessitates targeted monitoring and individualized management.

KEYWORDS: Lipid disorders, Hemodialysis, Dyslipidemia, Cardiovascular events, chronic kidney disease, Hypolipidemia

INTRODUCTION

Dyslipidemia is highly prevalent among patients undergoing chronic hemodialysis (HD), affecting approximately 60–82% of individuals depending on population characteristics and dialysis modality [1]. Cardiovascular disease (CVD) remains the leading cause of morbidity and mortality in this population, with dyslipidemia playing a central role in accelerating vascular complications [2,3]. Unlike the general population, HD patients exhibit a distinct lipid pattern characterized by hypertriglyceridemia due to impaired lipoprotein lipase activity and reduced clearance of triglyceride-rich lipoproteins, along with decreased HDL levels and variable or paradoxically low LDL and total cholesterol levels [2,3]. These abnormalities are further compounded by qualitative lipoprotein dysfunction, including reduced antioxidant and anti-inflammatory properties of HDL, contributing to enhanced atherogenesis [6].

A unique phenomenon termed “reverse epidemiology” is observed in HD patients, where traditionally protective factors such as low total cholesterol and LDL are paradoxically associated with increased mortality [9]. This is largely attributed to the malnutrition–inflammation complex syndrome (MICS), in which low lipid levels reflect poor nutritional status and

chronic inflammation rather than reduced cardiovascular risk [10]. Consequently, the relationship between lipid parameters and outcomes in HD patients is complex, often demonstrating a U-shaped association with mortality [10,11]. Among lipid abnormalities, elevated lipoprotein(a) [Lp(a)] is particularly significant, with levels often two to three times higher than in the general population [7]. Lp(a) contributes to both atherogenesis and thrombosis through its structural similarity to plasminogen, promoting vascular proliferation and impairing fibrinolysis [5]. Importantly, Lp(a) levels remain elevated irrespective of LDL control, contributing to residual cardiovascular risk despite statin therapy [13].

The pathophysiology of dyslipidemia in HD is driven by multiple metabolic and enzymatic disturbances. Reduced activity of lipoprotein lipase (LPL) and hepatic lipase leads to accumulation of atherogenic remnant lipoproteins, while decreased lecithin–cholesterol acyltransferase (LCAT) activity results in dysfunctional HDL [6]. Uremic toxins, oxidative stress, and chronic inflammation further impair lipid metabolism by altering apolipoprotein structure and suppressing peroxisome proliferator-activated receptor-alpha (PPAR-α) activity, thereby worsening hypertriglyceridemia [15].

The distribution of lipid abnormalities in HD patients is influenced by both traditional risk factors, such as diabetes, hypertension, obesity, and age, and uremia-specific factors including chronic inflammation, oxidative stress, and protein-energy wasting [1,6]. Dialysis-related factors also play a significant role. Hemodialysis can acutely alter lipid levels through hemodilution, membrane adsorption, and dialysate composition, often leading to transient reductions in lipid concentrations post-dialysis [9,17]. Bio-incompatible membranes and acetate-based dialysates may exacerbate inflammation and oxidative stress, whereas citrate-based dialysates may improve triglyceride levels and HDL function, although long-term benefits remain uncertain [18,19].

Longitudinal monitoring of lipid profiles in HD patients provides greater prognostic value than single measurements, as lipid trends reflect underlying nutritional and inflammatory status [9,22]. Additionally, dialysis modality influences lipid patterns; peritoneal dialysis is associated with more atherogenic profiles due to continuous glucose exposure, while HD patients demonstrate more pronounced HDL dysfunction and elevated Lp(a) levels [22,23].

Despite the high burden of dyslipidemia, conventional lipid-lowering therapies such as statins have shown limited benefit in reducing cardiovascular events in HD patients, as demonstrated in major trials like AURORA and 4D [24,25]. This is likely due to the predominance of non-traditional risk factors, including inflammation, vascular calcification, and lipoprotein dysfunction, which are not adequately addressed by standard therapies [9]. Current guidelines therefore recommend cautious and individualized use of statins in this population [26].

Significant knowledge gaps remain in understanding the role of qualitative lipoprotein abnormalities, genetic determinants, and dialysis-specific factors in cardiovascular risk. Emerging therapies, including PCSK9 inhibitors and apolipoprotein(a)-targeted agents, show promise but require further evaluation in HD populations [13,15]. Future research integrating lipidomics, inflammatory biomarkers, and genetic profiling may enable more precise and personalized management of dyslipidemia in patients undergoing hemodialysis [26].

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MATERIALS AND METHODS

This serial cross-sectional study was conducted over 10 months (July 2024–April 2025) in the Departments of Medicine and Nephrology at Sree Balaji Medical College & Hospital, including 150 adult patients with end-stage renal disease (ESRD) on maintenance hemodialysis selected through purposive sampling. Patients with acute kidney injury, chronic liver disease, or on hypolipidemic drugs were excluded. The sample size was calculated using a correlation coefficient formula ($r = 0.93$, 95% confidence level, 80% power). After obtaining ethical approval and informed consent, baseline demographic, clinical, and anthropometric data were recorded. Fasting blood samples were collected pre- and post-hemodialysis to assess lipid profiles and serum albumin, while cardiovascular evaluation was performed using ECG and 2D echocardiography. Data collection followed standardized protocols with quality control measures, including instrument calibration and duplicate readings. A pilot study confirmed feasibility. Statistical analysis included descriptive statistics, paired t-tests for pre- and post-dialysis comparisons, and regression analysis to identify determinants of lipid abnormalities and cardiovascular events.

RESULT

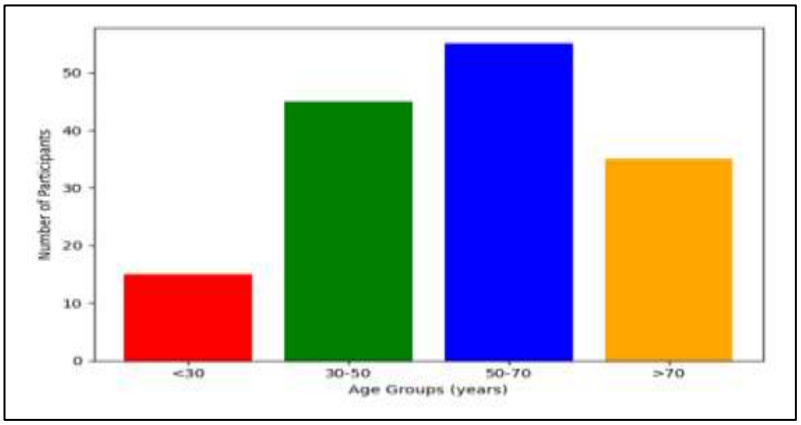

Figure 1: Age Distribution of Study Participants

Figure 1 displays that the study population (n = 150) had a mean age of 54.98 ± 18.15 years, with a median of 56.50 years (IQR: 40.75–71.25 years) and a range of 19 to 85 years, indicating a broad age distribution. The close similarity between the mean and median suggests a relatively symmetric distribution, with a predominance of middle-aged and elderly individuals.

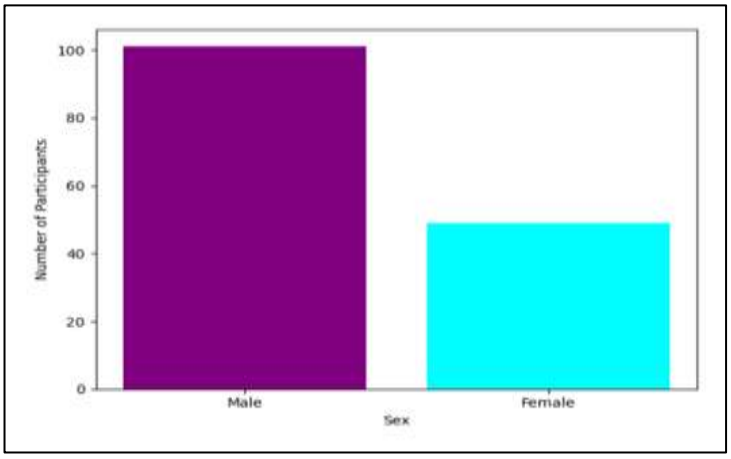

Figure 2: Sex Distribution of Study Participants

Figure 2 shows that among the study participants (n = 150), males constituted the majority with 101 individuals (67.00%), while females accounted for 49 individuals (33.00%). This indicates a clear male predominance in the study population.

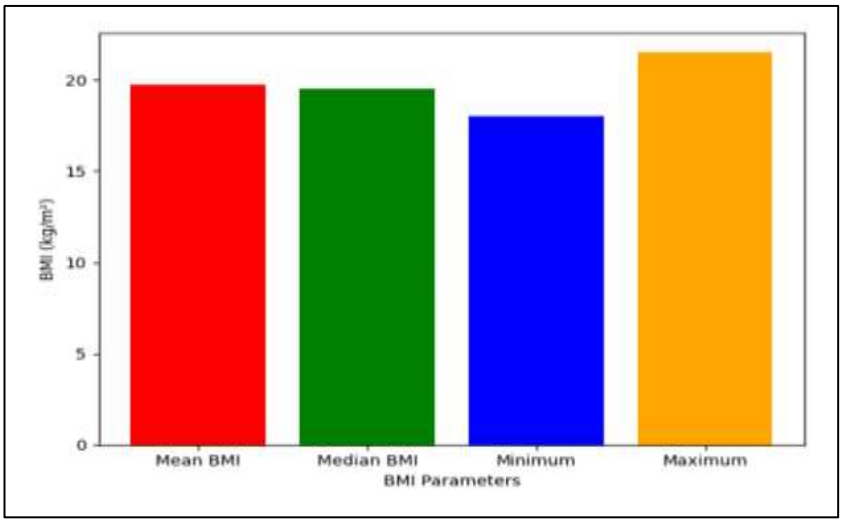

Figure 3: Distribution of Body Mass Index (BMI) among Study Participants

Figure 3 observable that the mean BMI of the study participants was 19.73 ± 1.14 kg/m², with a median value of 19.50 kg/m². BMI values ranged from 18.00 to 21.50 kg/m², indicating that most participants were clustered within the lower-normal BMI range.

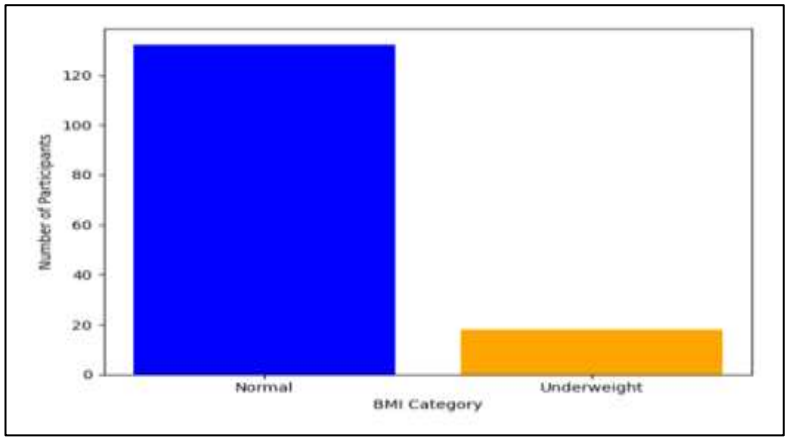

Figure 4: Distribution of BMI Categories

Figure 4 focuses on BMI categorization; the majority of study participants (132; 88.00%) belonged to the normal BMI category, while 18 participants (12.00%) were classified as underweight. This indicates that most participants had a BMI within the normal range at presentation.

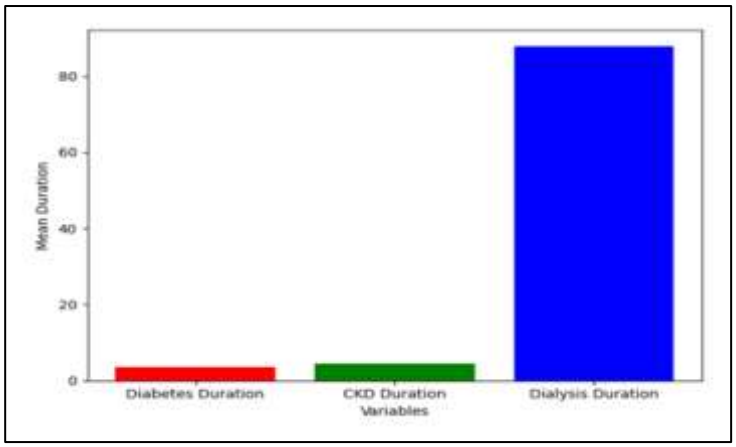

Figure 5: Distribution of Duration of Diabetes, CKD, and Hemodialysis

Figure 5 shows that the mean duration of diabetes among the study participants was 3.50 ± 4.05 years, indicating relatively shorter disease duration in many individuals. The duration of chronic kidney disease averaged 4.49 ± 1.00 years, showing less variability. In contrast, the duration of hemodialysis was markedly higher at 87.76 ± 54.70 months, demonstrating substantial heterogeneity and indicating prolonged dialysis exposure in a significant proportion of patients. shorten

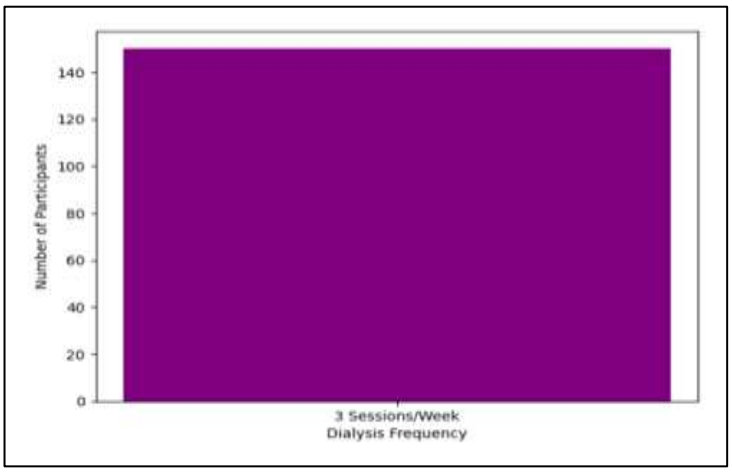

Figure 6: Distribution of Dialysis Frequency among Study Participants

All study participants (n = 150; 100.00%) were receiving hemodialysis three times per week, indicating a uniform dialysis schedule across the entire cohort (Figure 6).

Table 1: Distribution of Comorbidities among Study Participants

Comorbidity	Yes (n)	Yes (%)	No (n)	No (%)
Diabetes Mellitus	75	50.00	75	50.00
Hypertension	120	80.00	30	20.00
Coronary Artery Disease	38	25.00	112	75.00
Secondary Hyperparathyroidism	50	33.00	100	67.00

Table 1 shows the study participants (n = 150), hypertension was the most prevalent comorbidity, affecting 120 individuals (80.00%), followed by diabetes mellitus in 75 patients (50.00%). Secondary hyperparathyroidism was present in 50 patients (33.00%), while coronary artery disease was observed in 38 patients (25.00%). These findings indicate a high burden of cardiovascular and metabolic comorbidities in the study population

Table 2: Descriptive Statistics of Pre-HD and Post-HD Biochemical Parameters

Parameter	Mean	SD	Minimum	Maximum
Pre-HD Total Cholesterol (mg/dL)	176.49	27.37	130	220

Pre-HD LDL (mg/dL)	95.66	30.64	30	147.97
Pre-HD HDL (mg/dL)	40.52	7.13	25.81	55.32
Pre-HD Triglycerides (mg/dL)	201.71	59.28	101.09	336.81
Pre-HD VLDL (mg/dL)	40.34	11.86	20.22	67.36
Pre-HD Serum Albumin (g/dL)	3	0.14	2.8	3.2
Pre-HD Urea (mg/dL)	140	34	80	200
Pre-HD Creatinine (mg/dL)	6.8	1.75	4	10
Post-HD Total Cholesterol (mg/dL)	165.1	26.8	120	210
Post-HD LDL (mg/dL)	86.2	28.75	25	140
Post-HD HDL (mg/dL)	41.3	7.05	26	56
Post-HD Triglycerides (mg/dL)	203.1	58.9	95	330
Post-HD VLDL (mg/dL)	36.8	10.95	19	66
Post-HD Serum Albumin (g/dL)	2.8	0.14	2.6	3
Post-HD Urea (mg/dL)	110	30	60	170
Post-HD Creatinine (mg/dL)	5.8	1.6	3.5	9

Table 2 indicates that hemodialysis led to a reduction in total cholesterol, LDL, and VLDL, indicating decreased atherogenic lipids, while HDL showed a slight increase and triglycerides remained unchanged. Urea and creatinine levels declined post-dialysis, reflecting improved renal parameters, whereas serum albumin showed a mild decrease, likely due to intradialytic fluid shifts.

Table 3: Association between ECG Abnormality and LVH on ECG

ECG Abnormality	LVH on ECG – No n (%)	LVH on ECG – Yes n (%)	Total
No	75 (100.00)	0 (0.00)	75
Yes	38 (50.00)	37 (50.00)	75
Total	113	37	150

Among 150 participants, 50% had ECG abnormalities, and LVH was present in 25%, occurring exclusively in those with abnormal ECGs, indicating a strong association between ECG changes and LVH (Table 3).

Table 4: Descriptive Statistics of 2D Echo Ejection Fraction

Statistic	Value
Mean EF (%)	53.73
Standard Deviation (%)	10.33
Median EF (%)	54.5
Minimum EF (%)	35
Maximum EF (%)	70

The table 4 shows the mean left ventricular ejection fraction (EF) of the study population was 53.73 ± 10.33%, with a median value of 54.50%. EF values ranged from 35% to 70%, indicating considerable variability in cardiac function. While most participants had preserved systolic function, the presence of lower EF values suggests that a subset of patients exhibited varying degrees of systolic dysfunction.

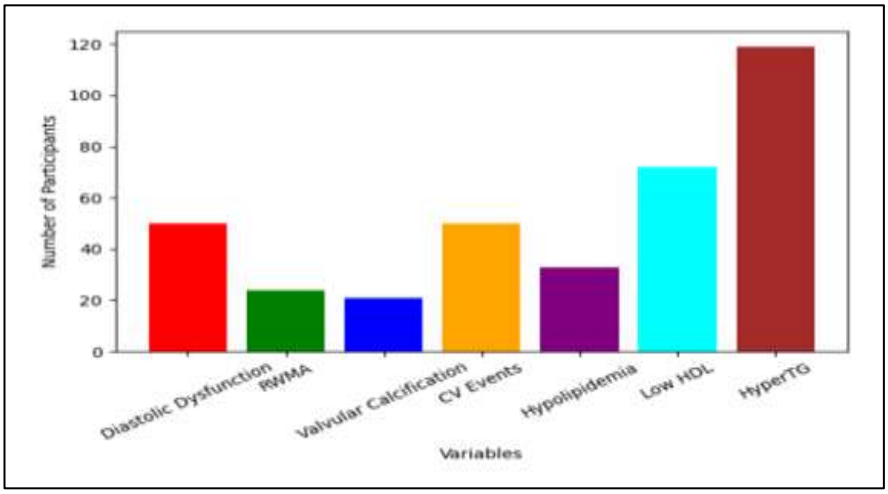

Figure 7: Distribution of Cardiac and Lipid Abnormalities among Study Participants

Figure 7 Diastolic dysfunction and cardiovascular events were each seen in 33% of patients, with regional wall motion abnormalities in 16% and valvular calcification in 14%. Hypertriglyceridemia (79%) was the most common lipid abnormality, followed by low HDL (48%) and hypolipidemia (22%), indicating a high burden of cardiovascular disease and dyslipidemia.

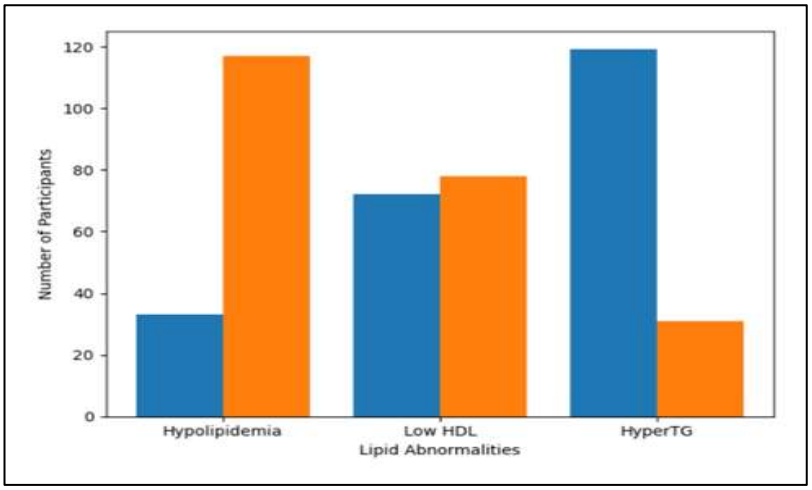

Figure 8: Distribution of Lipid Abnormalities among Study Participants

Hypertriglyceridemia was the most common abnormality (79%), followed by low HDL (48%) and hypolipidemia (22%), demonstrating the coexistence of atherogenic dyslipidemia and low lipid states in hemodialysis patients (Figure 8).

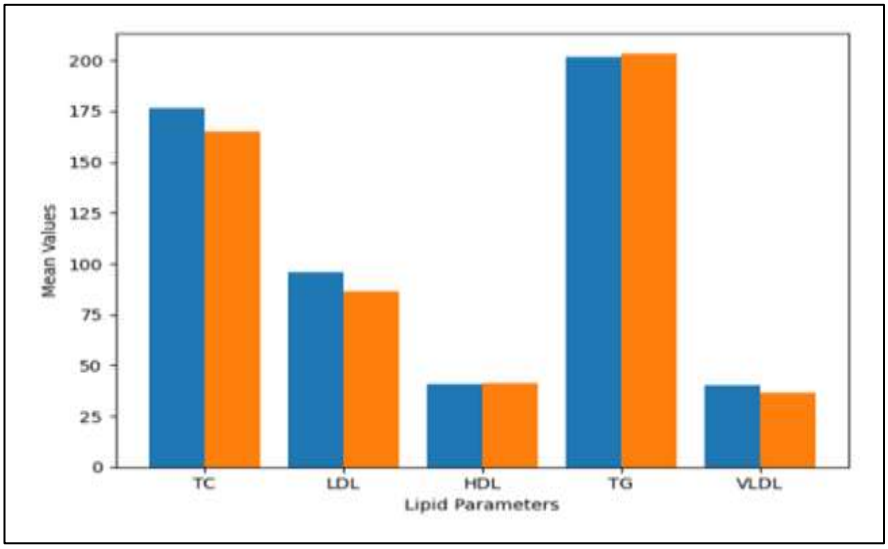

Figure 9: Comparison of Mean Lipid Parameters before and after Hemodialysis

Hemodialysis reduced total cholesterol, LDL, and VLDL, with a slight increase in HDL and minimal change in triglycerides, indicating selective improvement in atherogenic lipids (Figure 9).

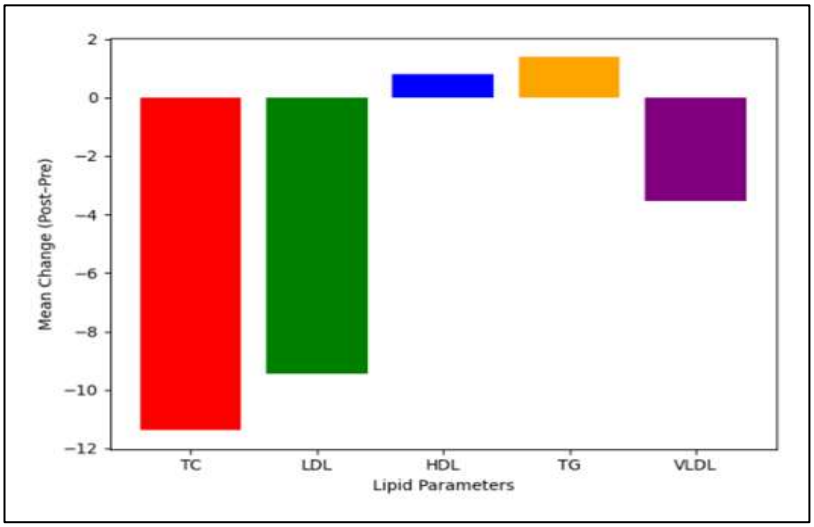

Figure 10: Mean Change in Lipid Parameters following Hemodialysis

Hemodialysis reduced total cholesterol, LDL, and VLDL, while HDL showed a slight increase and triglycerides a minimal rise, indicating decreased atherogenic lipids with little effect on HDL and triglycerides (Figure 10).

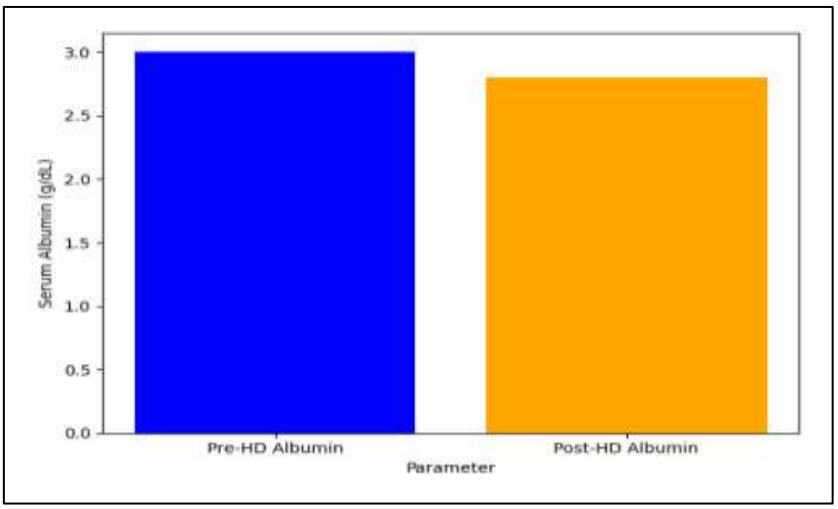

Figure 11. Serum Albumin Levels before and after Hemodialysis

Serum albumin levels showed a decline following hemodialysis, with mean values decreasing from 3.00 ± 0.14 g/dL pre-dialysis to 2.80 ± 0.14 g/dL post-dialysis. This reduction reflects the effect of intradialytic fluid shifts and possible albumin loss during the dialysis process (Figure 11).

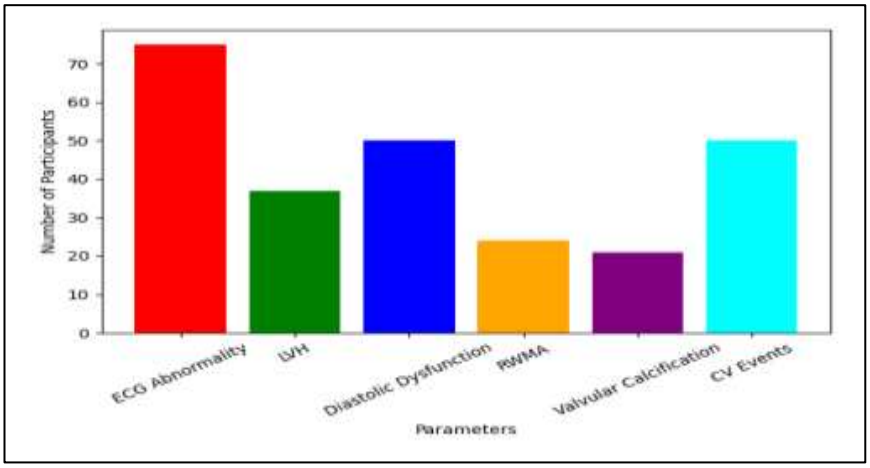

Figure 12. Distribution of ECG and Echocardiographic Abnormalities

Among the study participants (n = 150), ECG abnormalities were observed in 75 patients (50.00%). Left ventricular hypertrophy was present in 37 patients (25.00%). Diastolic dysfunction and cardiovascular events were each noted in 50 patients (33.00%). Regional wall motion abnormalities were present in 24 patients (16.00%), while valvular calcification was observed in 21 patients (14.00%). These findings indicate a high prevalence of cardiovascular abnormalities in patients undergoing maintenance hemodialysis (Figure 12).

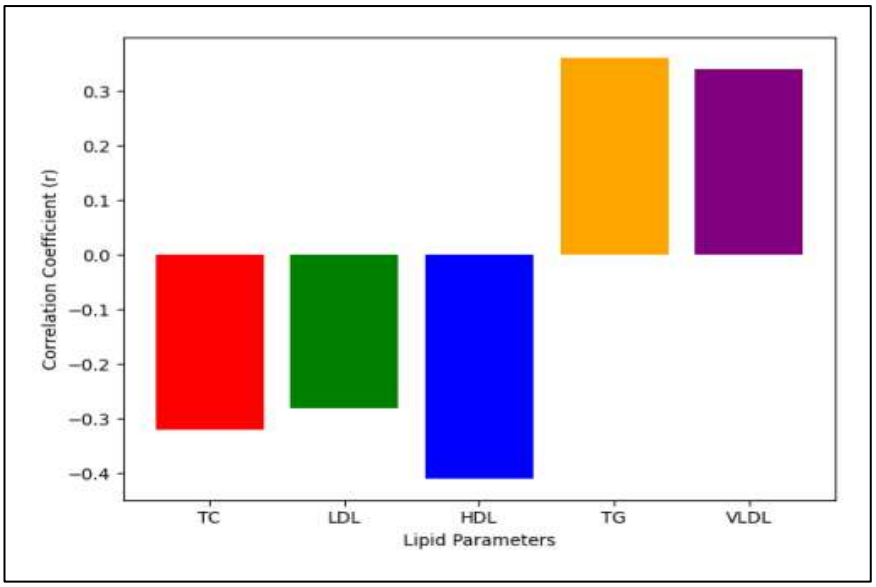

Figure 13. Correlation of Serum Creatinine with Lipid Parameters

Correlation analysis demonstrated that serum creatinine had a negative correlation with total cholesterol ($r = -0.32$), LDL ($r = -0.28$), and HDL ($r = -0.41$), indicating that worsening renal function was associated with lower cholesterol levels. In contrast, a positive correlation was observed with triglycerides ($r = 0.36$) and VLDL ($r = 0.34$), suggesting an increase in triglyceride-rich lipoproteins with advancing renal impairment. These findings reflect the characteristic dyslipidemia associated with chronic kidney disease (Figure 13).

DISCUSSION

The present study was conducted to evaluate the distribution and determinants of reverse epidemiology in lipid disorders among patients undergoing maintenance hemodialysis (HD). Dyslipidemia is highly prevalent in this population, affecting nearly 60–82% of patients and significantly contributing to the elevated burden of cardiovascular disease (CVD). Unlike the general population, lipid abnormalities in HD patients demonstrate a distinct and complex pattern, typically characterized by hypertriglyceridemia, reduced high-density lipoprotein cholesterol (HDL-C), and variable low-density lipoprotein cholesterol (LDL-C) levels, which may appear normal or even reduced. This atypical lipid profile reflects the phenomenon of reverse epidemiology, wherein lower levels of total cholesterol and LDL-C are paradoxically associated with increased mortality, often serving as markers of malnutrition–inflammation complex syndrome (MICS) rather than indicators of reduced cardiovascular risk. In addition, elevated lipoprotein(a), reduced lipoprotein lipase and lecithin–cholesterol acyltransferase (LCAT) activity, oxidative stress induced by uremia, and chronic systemic inflammation further contribute to dysfunctional lipid metabolism and accelerated atherogenesis. Dialysis-related factors, including membrane interactions and dialysate composition, along with differences in dialysis modality, also influence lipid levels and their interpretation. Furthermore, longitudinal lipid trends appear to provide greater prognostic value than single measurements, reflecting the dynamic interplay between nutrition, inflammation, and metabolic status. Despite reductions in LDL-C achieved with statin therapy, cardiovascular benefits remain limited in HD patients, largely due to the predominance of non-traditional risk factors such as inflammation, oxidative stress, and vascular calcification.

The demographic profile of the study population showed a mean age of 54.98 ± 18.15 years, with a relatively symmetrical distribution indicated by the close proximity of mean and median values. The wide age range (19–85 years) reflects the heterogeneity of the ESRD population, although a predominance of middle-aged and elderly individuals was observed. These findings are comparable with studies by N. Maheshwari (2010) and H. Abo-Zenah (2007), who reported similar age distributions among hemodialysis patients, supporting the observation that ESRD commonly affects middle-aged populations with a broad age spectrum [34,28]. A clear male predominance was noted, with males constituting 67% of the study cohort, which is consistent with previous reports by N. Maheshwari (2010) and I. Gorsane (2015), suggesting a higher representation of males in dialysis populations, possibly due to increased prevalence of risk factors such as diabetes and hypertension, as well as differences in healthcare access and utilization [27,29].

Nutritional assessment using body mass index (BMI) revealed a mean value of 19.73 ± 1.14 kg/m², with most participants falling within the lower-normal range. Although 88% of patients were categorized as having normal BMI, a notable proportion (12%) were underweight, indicating the presence of protein-energy wasting, which is commonly observed in hemodialysis patients. These findings are in agreement with previous studies, including N. Maheshwari (2010) and M.

Bossola (2008), which highlighted the variability in BMI among dialysis patients and emphasized the impact of malnutrition and inflammation on body composition [27,30]. The distribution of BMI categories further supports the presence of underlying metabolic disturbances, with normal BMI predominating but with evidence of nutritional compromise in a subset of patients.

The duration of comorbid conditions and dialysis exposure provides additional insight into disease burden. The mean duration of diabetes was 3.50 ± 4.05 years, while chronic kidney disease (CKD) duration averaged 4.49 ± 1.00 years, indicating relatively recent onset in many patients. In contrast, the duration of hemodialysis was significantly longer (87.76 ± 54.70 months), reflecting prolonged treatment dependency and considerable variability among individuals. These findings are consistent with previous literature, which identifies diabetes mellitus and hypertension as the leading causes of ESRD and highlights the chronic nature of dialysis therapy [27,29]. In the present study, hypertension was the most prevalent comorbidity (80%), followed by diabetes mellitus (50%), secondary hyperparathyroidism (33%), and coronary artery disease (25%), underscoring the high burden of cardiovascular and metabolic risk factors in this population.

Biochemical analysis revealed a characteristic dyslipidemic profile in HD patients. Pre-dialysis lipid levels showed elevated total cholesterol, LDL-C, triglycerides, and very-low-density lipoprotein (VLDL), along with reduced HDL-C. Following hemodialysis, there was a significant reduction in total cholesterol, LDL-C, and VLDL levels, while triglycerides showed minimal change and HDL-C remained largely unchanged. These findings indicate that hemodialysis exerts a selective effect on lipid fractions, reducing atherogenic lipoproteins but failing to normalize overall lipid metabolism. Similar patterns have been reported in studies by N. Maheshwari (2010) and S. Tauqeer (2018), which demonstrated persistent dyslipidemia in dialysis patients despite treatment, particularly with regard to elevated triglycerides and low HDL-C levels [27,31]. The persistence of these abnormalities suggests that dialysis alone is insufficient to correct the underlying metabolic derangements.

Cardiovascular assessment revealed a substantial burden of structural and functional abnormalities. Electrocardiographic (ECG) abnormalities were observed in 50% of patients, with left ventricular hypertrophy (LVH) present in 25%, exclusively among those with abnormal ECG findings. These findings indicate a strong association between electrical abnormalities and structural cardiac remodeling. Similar observations have been reported by S. Yamaguchi (2021), who demonstrated significant associations between ECG abnormalities, including LVH, and adverse cardiovascular outcomes [32]. Echocardiographic evaluation further revealed diastolic dysfunction in 33% of patients, regional wall motion abnormalities in 16%, and valvular calcification in 14%, while the mean ejection fraction remained relatively preserved (53.73 ± 10.33%). These findings highlight that significant cardiovascular pathology can exist even in the presence of preserved systolic function, emphasizing the importance of comprehensive cardiac evaluation in HD patients [32].

The prevalence of lipid abnormalities in the study population was notable, with hypertriglyceridemia being the most common (79%), followed by low HDL (48%) and hypolipidemia (22%). This coexistence of atherogenic dyslipidemia and low lipid states reflects the dual impact of metabolic dysfunction and reverse epidemiology. Comparable findings have been reported in previous studies, including S. Tauqeer (2018) and EC Samouilidou (2012), which also demonstrated elevated triglycerides, reduced HDL-C, and increased oxidative stress markers in dialysis patients, contributing to heightened cardiovascular risk [31,33].

Paired comparisons of lipid parameters before and after hemodialysis demonstrated significant reductions in total cholesterol, LDL-C, and VLDL, while HDL-C showed a non-significant increase and triglycerides remained largely unchanged. The mean changes further confirmed a selective reduction in atherogenic lipids, with minimal improvement in protective lipid fractions. These findings are consistent with NK Maurya (2018), who reported improved lipid profiles with regular dialysis but persistent abnormalities in triglycerides and HDL-C, highlighting the limited corrective effect of dialysis on lipid metabolism [34]. Additionally, serum albumin levels showed a significant decline following hemodialysis, reflecting intradialytic losses, fluid shifts, and ongoing protein-energy wasting, which may adversely affect patient outcomes.

The study also demonstrated a high prevalence of cardiovascular abnormalities detected by ECG and echocardiography, including LVH, diastolic dysfunction, and valvular calcification, along with a significant proportion of patients experiencing cardiovascular events. These findings are consistent with previous studies emphasizing the strong association between structural cardiac changes and adverse outcomes in HD patients [32]. Correlation analysis further revealed that worsening renal function, as indicated by higher serum creatinine levels, was associated with lower total cholesterol, LDL-C, and HDL-C, while showing a positive association with triglycerides and VLDL. This pattern strongly supports the concept of reverse epidemiology, where declining renal function is linked to altered lipid metabolism characterized by reduced cholesterol levels and increased triglyceride-rich lipoproteins.

Despite the valuable insights provided, the study has certain limitations. Being a single-center study with a relatively modest sample size, the findings may not be fully generalizable. The cross-sectional design limits the ability to establish causal relationships, and important confounding factors such as dietary intake, inflammatory markers, and medication use were not comprehensively evaluated. Additionally, advanced lipid parameters, including apolipoproteins and lipoprotein(a), were not assessed, and long-term follow-up data were not available. The clinical implications of this study are significant. The findings highlight the need for cautious interpretation of lipid profiles in HD patients, taking into account nutritional and inflammatory status rather than relying solely on conventional lipid targets. The high burden of cardiovascular abnormalities underscores the importance of regular cardiac monitoring, while management strategies should focus on addressing both traditional and non-traditional risk factors, including inflammation, malnutrition, and oxidative stress [32,34].

In conclusion, patients undergoing maintenance hemodialysis experience a complex interplay of metabolic and cardiovascular abnormalities, with dyslipidemia being a central feature. The lipid profile is characterized by

hypertriglyceridemia, low HDL, and paradoxical hypolipidemia, reflecting reverse epidemiology. Hemodialysis leads to partial improvement in atherogenic lipid fractions but does not fully correct lipid abnormalities, while serum albumin decline indicates ongoing nutritional and inflammatory challenges. The high prevalence of cardiovascular abnormalities, including LVH, diastolic dysfunction, and cardiovascular events, highlights the substantial cardiovascular risk in this population. Furthermore, the observed correlations between renal function and lipid parameters reinforce the altered metabolic landscape of ESRD. Overall, these findings emphasize the need for comprehensive, individualized approaches to risk assessment and management, integrating metabolic, nutritional, and cardiovascular factors to improve outcomes in patients undergoing hemodialysis.

CONCLUSION

The present study demonstrates that patients on maintenance hemodialysis exhibit a distinct clinical and biochemical profile characterized by middle-aged predominance, relatively low BMI, and a high burden of comorbidities such as hypertension and diabetes. The lipid pattern reflects uremic dyslipidemia, with elevated triglycerides, reduced HDL, and paradoxically low total and LDL cholesterol, supporting the concept of reverse epidemiology. Hemodialysis leads to a modest but significant reduction in atherogenic lipids, while HDL and triglycerides remain largely unchanged, and serum albumin declines post-dialysis, indicating ongoing nutritional and inflammatory stress. A high prevalence of cardiovascular abnormalities further underscores the risk in this population, and the observed association between worsening renal function and adverse lipid changes highlights the impact of the uremic milieu. Overall, these findings suggest that management should prioritize control of inflammation, malnutrition, and uremia rather than focusing solely on conventional lipid-lowering strategies.

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