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Association of Serum Lipid Profile Abnormalities with Early Atherosclerotic Changes Assessed by Carotid Intima-Media Thickness in Adults with Hyperlipidemia

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ABSTRACT

Background: Hyperlipidemia is a significant risk factor that can contribute to atherosclerosis and cardiovascular disease, which is modifiable. Silent structural changes in the vascularity before clinical signs appear are commonplace. Carotid intima-media thickness (CIMT) is a proven non-invasive measurement of the early atherosclerotic changes.

Objectives: To evaluate the association between serum lipid profile abnormalities and early atherosclerotic alterations, assessed through CIMT, in adults with hyperlipidemia.

Methods: It was a cross-sectional study that involved 100 adults who were known to have hyperlipidemia. Standardized enzymatic methods were used to measure fasting serum lipid parameters, comprising the total cholesterol, LDL-C, HDL-C, and triglycerides. High-resolution B-mode ultrasonography was used to determine the bilateral assessment of CIMT. Correlation and regression tests were done to identify relationships between lipid parameters and CIMT.

Results: The average CIMT was 0.81 (0.11) mm with 63 per cent. of the people showing an increase in CIMT. Anywhere there were significant positive relationships found between CIMT and total cholesterol ($p < 0.05$), LDL-C ($p < 0.05$), and triglycerides ($p < 0.05$). The HDL-C had a significant negative relationship with CIMT. Significant predictors of a greater CIMT in the presence of confounders were LDL-C.

Conclusion: Early non-clinical atherosclerotic alterations are strongly linked with serum lipid abnormalities. CIMT is an effective instrument for stratifying the cardiovascular risks of hyperlipidemic adults at the beginning. Dyslipidemia can be identified and treated early to decrease cardiovascular morbidity in the future.

Key words: Hyperlipidemia, Atherosclerosis, CIMT, Dyslipidemia, Triglycerides, Cardiovascular

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INTRODUCTION

Atherosclerosis refers to a chronic progressive vascular disease that is accompanied by dysfunction of the endothelial cells, lipid deposition, inflammation, and structural remodeling of the arterial wall. Its onset is silent over a long period of time, long before clinical cardiovascular events, including myocardial infarction, stroke, or peripheral arterial disease, develop [1]. Hyperlipidemia is one of the many cardiovascular risk factors that is core to the establishment and development of atherosclerotic plaque [2]. Raised serum lipids, especially low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), and the occurrence of atherogenic lipoprotein subfractions, are direct causes of lipid deposition in the arterial intima, oxidative modification, and early vascular injury through pro-inflammatory signaling pathways. On the other hand, the protective lipoproteins like high-density lipoprotein cholesterol (HDL-C) assist in the preservation of the vascular integrity by reverse cholesterol transport and antioxidant properties, and the lack of them increases the vulnerability to premature atherosclerosis even more [3].

Early identification of subclinical atherosclerosis has thus been the focus in preventative cardiology, particularly in hyperlipidemic adults who might experience prolonged duration of stay without symptoms despite persistent vascular processes [4]. Carotid intima-media thickness (CIMT) has become a highly validated non-invasive imaging biomarker, which measures early arterial wall thickening preceding the formation of a radiologically visible plaque [5]. Higher levels of CIMT strongly correlate with conventional lipid irregularity, extensive inflammation, and cardiovascular danger. Notably, CIMT assessment enables clinicians to measure the extent of early vascular injury, classify high-risk individuals, as well as the vascular effects of therapeutic approaches like statins, lifestyle change, and new lipid-lowering therapies [6].

In a population with a high metabolic risk burden, such as poor eating, sedentary lifestyle, rising obesity, and unidentified lipid abnormalities, knowledge about the relationship between serum lipid profiles and initial atherosclerotic alterations is necessary to curtail cardiovascular morbidity and mortality in the long-term [7]. There is a lack of sufficient data on early vascular changes in many areas with low and middle income, even though dyslipidemia is increasingly becoming prevalent, which leads to late diagnosis and poor prevention measures [8]. The testing of CIMT in hyperlipidemia patients in adulthood provides a possible chance to prevent the emergence of the disease at the subclinical stage, inform risk-based therapy, and prevent the progression of subclinical vascular injury to the advanced atherosclerotic process [9]. The aim of the current study consists in exploring the relationship between abnormalities of serum lipid profile and early atherosclerotic alterations, examined by CIMT in hyperlipidemic adults. This relationship will help to predict risks better, intervene earlier clinically, and design specific preventive measures to decrease the cost of cardiovascular disease [10].

MATERIALS AND METHODS

The study was carried out in the Medical Outpatient Department and Cardiology Clinics of Bahawal Victoria Hospital (BVH), Bahawalpur, Pakistan, between June 2024 and June 2025 and involved 100 adult patients with hyperlipidemia. The participants were recruited by non-probability consecutive sampling according to the persistent abnormal levels of serum lipid as per the standard diagnostic parameters. The eligible ones had ages 30 to 65 years and had high levels of total cholesterol, low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), or low levels of high-density lipoprotein cholesterol (HDL-C).

The patients who had a known history of cardiovascular events, diabetes mellitus, chronic kidney disease, thyroid dysfunction, active infection, or had received lipid-lowering therapy over a period exceeding three months were eliminated to reduce confounding variables. On receiving informed consent in writing, demographic information, clinical history, blood pressure, height, weight, and body mass index (BMI) were recorded using a structured proforma, and other cardiovascular risk factors, including smoking and family history of premature cardiovascular disease, were also noted. Venous blood samples were fasted and examined to assess the total cholesterol, LDL-C, HDL-C, and triglycerides using automated enzymatic colorimetric analyses that were done in the central diagnostic laboratory of BVH with quality-controlled conditions.

Carotid intima-media thickness (CIMT) of all the participants was assessed by high-resolution B-mode ultrasonography of the far wall on the common carotid artery at around a 1 cm distance above the carotid bulb, on the right and left sides. Plaque-free arterial segments were measured, and three measurements were made on each side, and the mean CIMT value was measured to reduce variability. The ultrasound studies were conducted by one qualified radiologist with no prior knowledge of laboratory outcomes in an effort to reduce observer bias. The interpretation of CIMT values was based on international threshold criteria of early atherosclerotic changes.

The data were then put into a structured database and evaluated in terms of mean ± standard deviation, frequencies, and percentages as categorical variables, and correlation analysis with Pearson correlation and multivariate regression analysis as the relevant statistical software due to the use of continuous variables, and $p < 0.05$ was considered the level of statistical significance. The study was ethically approved by the institutional ethics review committee (IERC) of Bahawal Victoria Hospital (BVH), Bahawalpur, Pakistan, with reference number ERC/BVH/2024/023, and all the study procedures were conducted according to the institutional guidelines and the principles of the Declaration of Helsinki.

RESULTS

Total n=100 adults with hyperlipidemia were used in the final analysis who had hyperlipidemia. The average age of the participants in the study group was 48.65 years, with a standard deviation of 10.41, with 57 percent of the population being men and 43 percent being women. The mean BMI was 28.4 ± 3.9 kg/m². The lipid parameters in serum indicated a higher amount of total cholesterol, LDL-C, and triglycerides levels, with decreased HDL-C levels observed in a significant proportion of the subjects. Carotid ultrasonography showed inconsistent levels of elevated CIMT, which depict the initial atherosclerotic alterations in the participants as shown in table 1. Measurement of CIMT 2- CIMT showed that the mean right CIMT was 0.79 + 0.12 mm, the mean left CIMT was 0.82 + 0.11 mm, and the mean CIMT was 0.81 + 0.11 mm, indicating a high prevalence of early atherosclerotic

changes in adults with hyperlipidemia as shown in table 2.Correlation analysis revealed that there exists a statistically significant positive correlation between the mean CIMT and total cholesterol ($r = 0.41$, $p = 0.001$), LDL-C ($r = 0.46$, $p < 0.001$), and triglycerides ($r = 0.38$, $p = 0.002$). Negative association was found between the HDL-C and the CIMT ($r = -0.33$, $p = 0.005$), which showed that HDL-C had a protective effect on early atherosclerotic alterations. Regression analysis proved that LDL-C was the most significant independent predictor of increased CIMT as adjusted by age, sex, and BMI as shown in table 3.In general, the results indicated that there is a definite relationship between the abnormal serum lipid profiles and the early atherosclerotic vascular alterations in individuals with hyperlipidemia, and that LDL-C is the most correlated with the carotid wall thickening.

Table 1: Baseline Characteristics and Lipid Profile of Study Participants (N = 100)

Variable	Mean ± SD / n (%)
Age (years)	48.6 ± 10.4
Male gender	57 (57%)
Female gender	43 (43%)
BMI (kg/m²)	28.4 ± 3.9
Total Cholesterol (mg/dL)	226.5 ± 32.8
LDL-C (mg/dL)	148.2 ± 28.6
HDL-C (mg/dL)	38.4 ± 6.9
Triglycerides (mg/dL)	192.7 ± 41.3

Table 2: Carotid Intima-Media Thickness (CIMT) Measurements in Study Population

CIMT Parameter	Mean ± SD
Right CIMT (mm)	0.79 ± 0.12
Left CIMT (mm)	0.82 ± 0.11
Mean CIMT (mm)	0.81 ± 0.11
Increased CIMT ≥0.80 mm	63%

Table 3: Correlation of Serum Lipid Parameters with Mean CIMT

Lipid Parameter	Correlation Coefficient (r)	p-value
Total Cholesterol	0.41	0.001
LDL-C	0.46	<0.001
HDL-C	–0.33	0.005
Triglycerides	0.38	0.002

DISCUSSION

The current study examined the correlation between abnormalities of the lipid profile of serum and premature atherosclerotic alterations that were measured by carotid intima-media thickness (CIMT) among adults with hyperlipidemia. The results of the current analysis prove the significant correlation between dyslipidemia and augmented CIMT, which supports the long-standing position of lipid abnormalities in the pathogenesis of subclinical atherosclerosis [11]. The fact that 63 percent of the participants had greater CIMT is an indication that structural changes in the vascular system may occur very early and silently in hyperlipidemic individuals, even in the absence of clinical cardiovascular conditions [12].

The correlation of high levels of total cholesterol, LDL-C, and triglycerides with CIMT in the current study contributes to the mechanistic concept that the central role of atherogenic lipoproteins is the lead causes of early damage to the arterial wall [13]. It was found to be most correlated with LDL-C ($r = 0.46$), which is in line with its significant role in causing endothelial dysfunction, oxidative stress, and lipid deposition to the intimal layer. The former is upheld by the earlier literature that suggests that LDL-C rise is hastening the thickening of the carotid wall and predisposes future cardiovascular events [14]. This close association between triglycerides and CIMT once again emphasizes the contributions made by triglyceride-containing lipoproteins and remnant cholesterol to early atherosclerotic disease due to its increasing utilization in the cardiovascular risk assessment in the modern world [15].

The hostile interaction between HDL-C and CIMT provides additional support for the safety of HDL-C on the condition of the vascularity as well. Due to its involvement in the reverse cholesterol transport, HDL-C helps to remove the excess cholesterol level in the peripheral tissue, in addition to the oxidative destruction of LDL particles. This can lead to a higher vulnerability to premature atherosclerotic changes in an environment that is not highly endowed in HDL-C, as witnessed in a high percentage of this group in this study [16]. The findings embrace the importance of a normal lipid profile on vascular integrity. CIMT has proved to be an appropriate non-invasive tool to identify the initial vascular events among this group. Considering that the CIMT measurement can be used to identify the presence of preclinical atherosclerosis, in the pre-plaque, or pre-luminal constriction stage, the CIMT is a timely risk stratification method that is applicable in patients with hyperlipidemia [17].

The relative prevalence of increased CIMT in this population is relatively high, and it means that there might be a significant percentage of patients possessing lipid abnormalities who might have undetected arterial alterations that could have been unobservable at the moment of the routine clinical evaluation. Recent findings concerning these individuals allow clinicians to improve lifestyle modification, initiate the use of lipid-lowering medications sooner, and evaluate the treatment acceptance more effectively. The results are also applicable to the population-based prevention of cardiovascular [18]. The issue of hyperlipidemia remains one of the primary and more widespread risk factors, particularly in those regions, the levels of which are growing due to the formation of a sedentary lifestyle, unhealthy dietary habits, overweight, and the impairment of metabolism. An immediate requirement to monitor the occurrence of dyslipidemia and subclinical atherosclerosis pathology on a routine basis, with additional risk modulators such as obesity, smoking, and family history of premature cardiovascular disease, correlates the relevant correlation of glaring lipid abnormalities and initial CIMT change to the surveillance of dyslipidemia and subclinical atherosclerosis pathology in the present population [19].

The strengths are standardized lab tests and even the use of high-resolution ultrasonography, which was performed by one skilled radiologist, and this factor minimized operator variability. Moreover, inclusion of a small number of lipid parameters and their correlation with CIMT would provide an in-depth look at how each of the lipid profile parameters contributes to the formation of early atherosclerotic events. However, restrictions must be admitted to a degree [20]. This is due to the fact that the design is not causal, and the study merely captures a point in time rather than a longitudinal course. Besides, although confounding disorders, such as diabetes and renal disease, were eliminated, residual confounding due to such factors as dietary habits, physical activities, and genetic predisposition cannot be discounted. In the future, bigger longitudinal studies will help establish the effect of CIMT on progression with time and the impacts of therapeutic interventions on vascular remodelling [12,15].

Overall, the findings are indicative of the existence of abnormal serum lipid profiles, specifically, high serum LDL-C and triglyceride, and low serum HDL-C levels, and their association with increased CIMT in hyperlipidemic patients. Such arterial structural changes have shown that there is a need to identify such early changes, aggressively work on lipids, and periodically check the vascular parameters to prevent cardiovascular issues in the future [19,20].

CONCLUSION

This study shows that dysfunctional serum lipid profiles were strongly connected to premature atherosclerotic changes, applying to carotid intima-media thickness (CIMT), in hyperlipidemic adults. The reverse and protective relationship between the lower level of HDL-C and high levels of total cholesterol, LDL-C, and triglycerides, and high levels of CIMT. LDL-C was found to be the best predictor of the premature thickening of the arterial wall. The results indicate the existence of subclinical atherosclerosis in hyperlipidemic patients and the necessity to screen lipids and non-invasively examine the vessel at an earlier stage. The early diagnosis and right treatment of dyslipidemia can aid in minimizing the cardiovascular risk in the future.

Conflict of Interest: The authors declare no conflicts of interest related to this study.

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Authors' Contributions:

A.S. conceived the study, designed the methodology, and drafted the manuscript.

J.M.A. conducted clinical evaluation, participant recruitment, and data acquisition.

M.H. performed laboratory oversight, data interpretation, statistical analysis, and critical revision of the manuscript. All authors reviewed and approved the final manuscript.

Data Availability Statement: Data supporting the findings of this study are available from the corresponding author upon reasonable request, in line with ethical and institutional guidelines.

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