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Original Research Article

ADVANCED LIPID MARKERS AS PREDICTORS OF PREMATURE CORONARY ARTERY DISEASE IN YOUNG INDIANS: INSIGHTS FROM A CASE-CONTROL STUDY

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Abstract

Background: Premature coronary artery disease (CAD) is increasingly prevalent among young Indians, with conventional lipid parameters often failing to provide adequate risk stratification. Advanced lipid markers, such as Lipoprotein(a), ApoB/ApoA1 ratio, and Small Dense LDL, have emerged as potential indicators of CAD risk. This study evaluates the reliability of these advanced lipid parameters in distinguishing cases of premature CAD from healthy controls. **Materials and Methods:** This case-control study included 296 patients with premature CAD (cases) and 296 age- and sex-matched controls. Serum levels of total cholesterol, LDL-C, HDL-C, triglycerides, Lipoprotein(a), ApoB, ApoA1, ApoB/ApoA1 ratio, and Small Dense LDL were measured and compared between groups. Receiver operating characteristic (ROC) curve analysis assessed the diagnostic accuracy of these lipid parameters. Logistic regression determined independent risk factors for premature CAD. **Result:** Cases exhibited significantly higher mean levels of total cholesterol (192.5 ± 34.8 mg/dL), LDL-C (125.3 ± 27.6 mg/dL), triglycerides (176.8 ± 45.2 mg/dL), Lipoprotein(a) (44.5 ± 19.8 mg/dL), ApoB (108.2 ± 22.5 mg/dL), ApoB/ApoA1 ratio (0.92 ± 0.26), and Small Dense LDL (42.7 ± 14.3 mg/dL) than controls ($p < 0.001$ for all). ROC analysis identified ApoB/ApoA1 ratio >0.85 (AUC = 0.83), Lipoprotein(a) >30 mg/dL (AUC = 0.81), and Small Dense LDL >40 mg/dL (AUC = 0.79) as strong discriminators of CAD. Multivariate analysis showed that ApoB/ApoA1 ratio >0.85 (OR = 3.12, 95% CI: 2.28–4.27), Lipoprotein(a) >30 mg/dL (OR = 2.85, 95% CI: 2.10–3.87), and Small Dense LDL >40 mg/dL (OR = 2.67, 95% CI: 1.95–3.65) were independent risk factors. **Conclusion:** Advanced lipid parameters, particularly Lipoprotein(a), ApoB/ApoA1 ratio, and Small Dense LDL, demonstrated higher predictive value than conventional lipid markers for premature CAD in young Indians. Their inclusion in routine lipid profiling may improve early detection and risk stratification, facilitating timely interventions.

INTRODUCTION

Coronary artery disease (CAD) remains the leading cause of mortality worldwide, contributing to approximately 17.9 million deaths annually, with a rising burden among younger populations, particularly in South Asia.[1] India has one of the highest incidences of premature CAD, defined as occurring before 45 years in men and 55 years in women, with nearly 25% of CAD-related deaths occurring in individuals under 40 years of age.[2] Compared to Western populations, Indians develop CAD nearly a decade earlier, often presenting with more severe disease and worse outcomes despite lower levels of traditional risk factors such as total cholesterol and low-density lipoprotein cholesterol (LDL-C).[3] This discrepancy has fueled interest in

advanced lipid parameters that may offer better risk stratification in young individuals.

Dyslipidemia is a key risk factor for CAD, with conventional lipid markers such as total cholesterol, LDL-C, high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) commonly used for risk assessment. However, these markers do not fully capture atherogenic risk, particularly in young CAD patients, as many present with normal or borderline LDL-C levels.[4,5]. Advanced lipid parameters, including lipoprotein(a) [Lp(a)], apolipoprotein B (ApoB), apolipoprotein A1 (ApoA1), small dense LDL (sdLDL), and lipid ratios such as ApoB/ApoA1, LDL/HDL, and TG/HDL, have shown superior predictive value for atherosclerosis and cardiovascular events.[6]

Lipoprotein(a), an LDL-like particle with a genetic basis, has been identified as a strong predictor of premature CAD. Indian populations exhibit significantly higher median Lp(a) levels than Western populations, with elevated levels (>50 mg/dL) nearly doubling the risk of myocardial infarction in young individuals, independent of LDL-C.[7,8] Similarly, ApoB, a marker of total atherogenic lipoproteins, has been shown to correlate more strongly with CAD risk than LDL-C alone, with higher levels linked to increased plaque burden and cardiovascular events.[9] The ApoB/ApoA1 ratio, representing the balance between atherogenic and anti-atherogenic lipoproteins, has been associated with a 3.5-fold higher risk of premature myocardial infarction.[10]

Small dense LDL (sdLDL) is another emerging lipid marker, considered more atherogenic than larger LDL particles due to its greater susceptibility to oxidation and enhanced arterial wall penetration. Young CAD patients frequently exhibit elevated sdLDL levels even with normal total LDL-C, making it a valuable marker for high-risk individuals.[11,12] Additionally, lipid ratios such as TG/HDL-C and LDL/HDL-C are linked to insulin resistance, metabolic syndrome, and subclinical atherosclerosis, further underscoring their role in premature CAD risk prediction.[13]

Despite these insights, the clinical utility of advanced lipid parameters in assessing premature CAD in young Indians remains underexplored. This study aims to evaluate the reliability of Lp(a), ApoB, ApoA1, sdLDL, and lipid ratios in risk stratification for premature CAD.

MATERIALS AND METHODS

Study Design and Setting: This hospital-based case-control study was conducted in the Department of General Medicine at Deen Dayal Upadhyaya Medical College, Churu, Rajasthan, over a period of two years, from June 2021 to May 2023. Institutional Ethics Committee approval was obtained prior to the initiation of the study, and written informed consent was secured from all participants before enrolment.

Study Population: The study population comprised two groups: cases and controls. The case group included young patients diagnosed with premature CAD, defined as CAD occurring at or before 45 years of age in males and 55 years in females. Diagnosis was confirmed based on clinical symptoms, electrocardiographic (ECG) findings indicative of ischemia, elevated cardiac biomarkers (troponins), and coronary angiographic evidence of at least one major epicardial coronary artery showing ≥50% luminal stenosis. Patients were recruited from the cardiology department, including those presenting with acute coronary syndrome or stable ischemic heart disease.

The control group consisted of age- and sex-matched individuals without a history of CAD, recruited from outpatient clinics and routine health check-ups. Controls were required to have normal ECG findings, no clinical symptoms suggestive of CAD, and no prior history of cardiovascular events. Participants with pre-existing chronic inflammatory disorders, chronic kidney disease (CKD), hepatic dysfunction, thyroid disorders, malignancy, or those on lipid-lowering therapy within the preceding three months were excluded from both groups to minimize confounding effects on lipid metabolism.

Sample Size Calculation: In calculating the sample size for our case-control study on advanced lipid parameters in young Indian patients with premature coronary artery disease (CAD), we utilized the standard formula for unmatched case-control studies: $n = (Z_{a}/_{2} + Z_{\beta})^2 \times 2p(1-p)/(p_1 - p_2)^2$, where $Z_{a}/_{2} = 1.96$ for a 95% confidence level, $Z_{\beta} = 0.84$ for 80% power, p_1 represents the expected prevalence of abnormal lipid parameters in cases, and p_2 represents their prevalence in controls. A prior study reported that 66.66% of premature CAD patients had normal total cholesterol and 33.33% had LDL-C <100 mg/dL, suggesting that traditional lipid markers may not fully capture lipid abnormalities. A minimum of 296 participants per group was required to achieve statistical significance.[14]

Data Collection and Laboratory Analysis: Comprehensive demographic and clinical data were collected using a structured proforma, including details on age, sex, body mass index (BMI), smoking status, hypertension, diabetes mellitus, family history of CAD, and medication history. Blood pressure was measured using a standardized sphygmomanometer, and anthropometric assessments, including weight, height, and waist circumference, were recorded following standard protocols.

Fasting venous blood samples were obtained from all participants following a minimum 12-hour fasting period. Traditional lipid parameters, including total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG), were measured using an enzymatic colorimetric method on an automated chemistry analyzer. The normal reference ranges were: TC <200 mg/dL, LDL-C <100 mg/dL, HDL-C >40 mg/dL (men) or >50 mg/dL (women), and TG

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<150 mg/dL. Advanced lipid parameters were assessed using specialized techniques: lipoprotein(a) [Lp(a)] and apolipoproteins (ApoB and ApoA1) were quantified using immunoturbidimetric assays, while small dense LDL (sdLDL) was measured using a precipitation-based method. The risk thresholds were defined as Lp(a) >50 mg/dL, ApoB >90 mg/dL, ApoA1 <120 mg/dL, and sdLDL >30 mg/dL. Derived lipid ratios, including ApoB/ApoA1, LDL/HDL, and TG/HDL, were calculated to evaluate their potential predictive value for premature CAD. The ApoB/ApoA1 ratio was determined by dividing ApoB by ApoA1, with values >0.8 indicating high risk. The LDL/HDL ratio was calculated as LDL-C divided by HDL-C, with a cutoff >3.0 associated with increased atherosclerotic risk. The TG/HDL ratio was obtained by dividing TG by HDL-C, where a value >3.5 suggested insulin resistance and cardiovascular risk.

Statistical Analysis: Statistical analyses were performed using SPSS version 20.0. Continuous variables were assessed for normality using the Shapiro-Wilk test. Normally distributed variables were expressed as mean ± standard deviation (SD) and compared between groups using the independent t-test. Categorical variables were expressed as frequencies (percentages) and analyzed using the chi-square test. The association of advanced lipid parameters with premature CAD was evaluated using logistic regression analysis, with odds ratios (OR) and 95% confidence intervals (CI) reported. Correlations between lipid indices and CAD severity were assessed using Pearson's or Spearman's correlation coefficients. Receiver operating characteristic (ROC) curve analysis was performed to determine the diagnostic accuracy of lipid parameters, with the area under the curve (AUC) calculated to compare predictive values. A p-value <0.05 was considered statistically significant.

RESULTS

Patients with premature CAD exhibited significantly altered lipid profiles compared to controls. Total cholesterol (192.5 ± 34.8 vs. 178.2 ± 30.4 mg/dL; p<0.001), LDL-C (125.3 ± 27.6 vs. 110.8 ± 25.9 mg/dL; p<0.001), and triglycerides (176.8 ± 45.2 vs. 142.5 ± 38.7 mg/dL; p<0.001) were markedly elevated, while HDL-C levels were lower (38.6 ± 8.2 vs. 46.9 ± 7.8 mg/dL; p<0.001). Notably, lipoprotein(a) [Lp(a)] (44.5 ± 19.8 vs. 24.7 ± 12.3 mg/dL; p<0.001), ApoB (108.2 ± 22.5 vs. 88.3 ± 18.7 mg/dL; p<0.001), and the ApoB/ApoA1 ratio (0.92 ± 0.26 vs. 0.67 ± 0.21; p<0.001) were significantly higher in cases, underscoring their role in premature CAD. Small dense LDL (sdLDL) was also elevated (42.7 ± 14.3 vs. 28.6 ± 10.5 mg/dL; p<0.001), indicating a more atherogenic lipid profile [Table 1].

Table 1: Baseline Characteristics of Study Participants.

Characteristic	Cases (n=296)	Controls (n=296)	p-value
	Frequency (%)/Mean ± SD		
Age (years)	42.5 ± 4.8	41.8 ± 5.1	0.085
Gender			
Male	235 (79.4%)	198 (66.9%)	0.0004
Female	61 (20.6%)	98 (33.1%)	
BMI (kg/m²)	26.8 ± 3.4	25.3 ± 3.1	<0.001
Hypertension	128 (43.2%)	96 (32.4%)	0.0049
Diabetes	112 (37.8%)	84 (28.4%)	0.0198
Smoking	154 (52.0%)	104 (35.1%)	<0.001
Family History of CAD	85 (28.7%)	48 (16.2%)	0.0007
Physical Activity (≥150 min/week)	74 (25.0%)	132 (44.6%)	<0.001
Alcohol Consumption	102 (34.5%)	76 (25.7%)	0.024
Mean Systolic BP (mmHg)	138.4 ± 12.6	126.7 ± 11.2	<0.001
Mean Diastolic BP (mmHg)	86.5 ± 8.4	80.3 ± 7.9	<0.001

Individuals diagnosed with premature coronary artery disease (CAD) showed significantly deranged lipid parameters compared to healthy controls. In addition to higher levels of total cholesterol (192.5 ± 34.8 vs. 178.2 ± 30.4 mg/dL; p<0.001), LDL-C (125.3 ± 27.6 vs. 110.8 ± 25.9 mg/dL; p<0.001), and triglycerides (176.8 ± 45.2 vs. 142.5 ± 38.7 mg/dL; p<0.001), and lower HDL-C (38.6 ± 8.2 vs. 46.9 ± 7.8 mg/dL; p<0.001), advanced lipid ratios also significantly differentiated cases from controls. These included higher LDL/HDL (3.35 ± 0.97 vs. 2.36 ± 0.85; p<0.001) and TG/HDL ratios (4.58 ± 1.73 vs. 3.03 ± 1.21; p<0.001). Atherogenic markers such as Lp(a) (44.5 ± 19.8 vs. 24.7 ± 12.3 mg/dL; p<0.001), ApoB (108.2 ± 22.5 vs. 88.3 ± 18.7 mg/dL; p<0.001), and ApoB/ApoA1 ratio (0.92 ± 0.26 vs. 0.67 ± 0.21; p<0.001) were markedly elevated, along with increased sdLDL levels (42.7 ± 14.3 vs. 28.6 ± 10.5 mg/dL; p<0.001), highlighting a more atherogenic and dyslipidemic profile in those with early-onset CAD [Table 2].

Table 2: Comparison of Lipid Parameters Between Cases and Controls.

Lipid Parameter	Cases (n=296)	Controls (n=296)	p-value
	Mean ± SD		
Total Cholesterol (mg/dL)	192.5 ± 34.8	178.2 ± 30.4	<0.001
LDL-C (mg/dL)	125.3 ± 27.6	110.8 ± 25.9	<0.001

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HDL-C (mg/dL)	38.6 ± 8.2	46.9 ± 7.8	<0.001
Triglycerides (mg/dL)	176.8 ± 45.2	142.5 ± 38.7	<0.001
LDL/HDL Ratio	3.35 ± 0.97	2.36 ± 0.85	<0.001
TG/HDL Ratio	4.58 ± 1.73	3.03 ± 1.21	<0.001
Lipoprotein(a) (mg/dL)	44.5 ± 19.8	24.7 ± 12.3	<0.001
ApoB (mg/dL)	108.2 ± 22.5	88.3 ± 18.7	<0.001
ApoB/ApoA1 Ratio	0.92 ± 0.26	0.67 ± 0.21	<0.001
Small Dense LDL (mg/dL)	42.7 ± 14.3	28.6 ± 10.5	<0.001

Receiver operating characteristic (ROC) analysis identified optimal cut-off values for lipid parameters in differentiating premature CAD cases from controls. An ApoB/ApoA1 ratio >0.85 demonstrated the highest diagnostic performance (AUC: 0.83, 95% CI: 0.78–0.87), with 80.2% sensitivity and 74.3% specificity. Lp(a) >30 mg/dL also showed strong predictive value (AUC: 0.81, 95% CI: 0.76–0.86), with 78.4% sensitivity and 72.6% specificity. Other markers such as sdLDL >40 mg/dL (AUC: 0.79, 95% CI: 0.74–0.84), LDL-C >120 mg/dL (AUC: 0.78, 95% CI: 0.73–0.82), and total cholesterol >190 mg/dL (AUC: 0.75, 95% CI: 0.70–0.80) also demonstrated moderate diagnostic accuracy, reinforcing the utility of advanced lipid parameters in early CAD detection [Table 3 and Figure 1].

Table 3: ROC Curve Analysis of Advanced Lipid Parameters for CAD Prediction.

Lipid Parameter	Cut-off Value	Sensitivity (%)	Specificity (%)	AUC (95% CI)
Total Cholesterol (mg/dL)	>190	72.5	68.9	0.75 (0.70–0.80)
LDL-C (mg/dL)	>120	74.8	71.2	0.78 (0.73–0.82)
Lipoprotein(a)	>30 mg/dL	78.4	72.6	0.81 (0.76–0.86)
ApoB/ApoA1 Ratio	>0.85	80.2	74.3	0.83 (0.78–0.87)
Small Dense LDL	>40 mg/dL	76.9	70.8	0.79 (0.74–0.84)

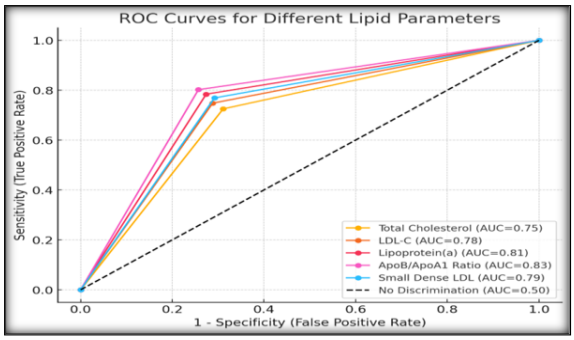

Figure 1: Receiver Operating Characteristic (ROC) Curves for Lipid Parameters in Predicting Premature Coronary Artery Disease

Lipoprotein(a) levels were significantly higher in individuals with premature CAD. A greater proportion of cases (31.4%) had Lp(a) >50 mg/dL compared to only 10.1% of controls (p<0.001). Similarly, Lp(a) levels between 31–50 mg/dL were more prevalent among cases (30.1%) than controls (18.9%) (p=0.001). In contrast, lower Lp(a) categories were more frequent among controls, with 36.5% having <10 mg/dL compared to only 14.2% of cases (p<0.001). These findings affirm the strong association between elevated Lp(a) levels and premature CAD [Table 4].

Table 4: Distribution of Lipoprotein(a) Levels Among Cases and Controls.

Lipoprotein(a) Category (mg/dL)	Cases (n=296)	Controls (n=296)	p-value
	Frequency (%)		
<10	42 (14.2%)	108 (36.5%)	<0.001
10–30	72 (24.3%)	102 (34.5%)	0.008
31–50	89 (30.1%)	56 (18.9%)	0.001
>50	93 (31.4%)	30 (10.1%)	<0.001

Multivariate logistic regression analysis identified several independent risk factors for premature CAD. Elevated Lp(a) levels (>30 mg/dL) were associated with a 2.85-fold increased risk (95% CI: 2.10–3.87, p<0.001), while an ApoB/ApoA1 ratio >0.85 showed the strongest association (OR: 3.12, 95% CI: 2.28–4.27, p<0.001). SdLDL >40 mg/dL was also significantly associated with increased CAD risk (OR: 2.67, 95% CI: 1.95–3.65, p<0.001). Among conventional risk factors, a family history of CAD (OR: 2.45, 95% CI: 1.82–3.29, p<0.001), hypertension (OR: 2.18, 95% CI: 1.64–2.92, p<0.001), and smoking (OR: 2.72, 95% CI: 2.01–3.68, p<0.001) also remained significant predictors [Table 5].

Table 5: Association Between Lipid Abnormalities and Myocardial Infarction (MI) Risk.

Variable	Adjusted OR (95% CI)	p-value
Lipoprotein(a) > 30 mg/dL	2.85 (2.10–3.87)	<0.001
ApoB/ApoA1 Ratio > 0.85	3.12 (2.28–4.27)	<0.001
Small Dense LDL > 40 mg/dL	2.67 (1.95–3.65)	<0.001
Family History of CAD	2.45 (1.82–3.29)	<0.001
Hypertension	2.18 (1.64–2.92)	<0.001
Smoking	2.72 (2.01–3.68)	<0.001

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DISCUSSION

Our study comprehensively evaluated the reliability of advanced lipid parameters in predicting premature coronary artery disease (CAD) in young Indians. The findings highlight significant alterations in lipid profiles among CAD cases compared to age-matched controls, with Lipoprotein(a) [Lp(a)], ApoB/ApoA1 ratio, and small dense LDL (sdLDL) emerging as strong predictors.

The lipid profile in CAD cases exhibited significantly higher mean levels of total cholesterol (192.5 ± 34.8 mg/dL vs. 178.2 ± 30.4 mg/dL, p<0.001), LDL-C (125.3 ± 27.6 mg/dL vs. 110.8 ± 25.9 mg/dL, p<0.001), and triglycerides (176.8 ± 45.2 mg/dL vs. 142.5 ± 38.7 mg/dL, p<0.001) compared to controls. In contrast, HDL-C was significantly lower in CAD cases (38.6 ± 8.2 mg/dL vs. 46.9 ± 7.8 mg/dL, p<0.001), confirming the well-established association between dyslipidemia and CAD risk. The LDL/HDL (3.35 ± 0.97 vs. 2.36 ± 0.85, p<0.001) and TG/HDL (4.58 ± 1.73 vs. 3.03 ± 1.21, p<0.001) ratios were also markedly elevated, reflecting the severity of atherogenic lipid abnormalities. These findings are in agreement with previous studies from India and other regions. A study by Deshmukh et al. on young Indian CAD patients also reported a significantly higher prevalence of elevated LDL-C and reduced HDL-C, reinforcing the role of lipid imbalance in early atherosclerosis [15]. Similarly, a case-control study by Patil et al. demonstrated that an abnormal ApoB/ApoA1 ratio contributed to more than 50% of the population-attributable risk for myocardial infarction (MI) across diverse ethnic groups.[16]

Lp(a) has long been recognized as an independent and genetically determined risk factor for CAD. Our study found that mean Lp(a) levels were significantly higher in cases (44.5 ± 19.8 mg/dL) compared to controls (24.7 ± 12.3 mg/dL, p<0.001). Notably, 31.4% of CAD patients had Lp(a) >50 mg/dL, compared to only 10.1% of controls (p<0.001). Multivariate analysis showed that Lp(a) >30 mg/dL was associated with an adjusted OR of 2.85 (95% CI: 2.10–3.87, p<0.001), underscoring its strong predictive value for premature CAD. These results are consistent with a study by Shukor et al., which identified Lp(a) as an independent determinant of early atherosclerotic cardiovascular disease (ASCVD).[17] A study by Chieng et al. further highlighted those individuals with Lp(a) levels exceeding 30 mg/dL had a 2- to 3-fold increased risk of CAD, even after adjusting for traditional risk factors.[18] In the Indian context, Joseph et al. and Yusuf et al. reported similar findings, emphasizing that Lp(a) levels are higher in South Asian populations compared to Western cohorts, potentially explaining the increased cardiovascular burden in young Indians.[19,20]

Our study also demonstrated the diagnostic potential of Lp(a) >30 mg/dL, which yielded 78.4% sensitivity and 72.6% specificity, with an AUC of 0.81 (95% CI: 0.76–0.86). This suggests that Lp(a) testing should be integrated into routine cardiovascular screening, particularly for young individuals at high risk. Apolipoprotein-based markers have been increasingly recognized as more reliable indicators of atherogenic lipid burden than traditional lipid parameters. Our findings revealed that CAD cases had a significantly higher ApoB/ApoA1 ratio (0.92 ± 0.26) compared to controls (0.67 ± 0.21, p<0.001). The diagnostic performance of an ApoB/ApoA1 ratio >0.85 demonstrated 80.2% sensitivity and 74.3% specificity, with an AUC of 0.83 (95% CI: 0.78–0.87), making it the most accurate lipid marker in our study. Our findings align with a previous study by Yaseen et al., which demonstrated that the ApoB/ApoA1 ratio was the strongest lipid predictor of myocardial infarction, outperforming LDL-C and total cholesterol.[21] A study by James et al. in Indian CAD patients similarly reported that an elevated ApoB/ApoA1 ratio was strongly associated with early-onset CAD, supporting its inclusion in risk assessment models.[22]

Among LDL subclasses, sdLDL is considered particularly atherogenic due to its higher oxidative susceptibility and increased arterial wall penetration. Our study found significantly elevated levels of sdLDL in CAD cases (42.7 ± 14.3 mg/dL) compared to controls (28.6 ± 10.5 mg/dL, p<0.001). The adjusted odds ratio for sdLDL >40 mg/dL was 2.67 (95% CI: 1.95–3.65, p<0.001), reinforcing its role as an independent risk factor. A study by Jin et al. highlighted that sdLDL is more predictive of CAD risk than total LDL-C, particularly in insulin-resistant populations.[23] In a study of young South Asian CAD patients, Ahmed et al. found that sdLDL levels were significantly higher in premature CAD cases and correlated with increased coronary plaque burden, further supporting our findings.[24]

Beyond lipid parameters, we found that a family history of CAD (OR: 2.45, 95% CI: 1.82–3.29), hypertension (OR: 2.18, 95% CI: 1.64–2.92), and smoking (OR: 2.72, 95% CI: 2.01–3.68), all with p<0.001, were significant predictors of premature CAD. These findings align with previous literature by Bilen et al. and Shah et al., which emphasize that South Asians have a distinct risk factor profile characterized by early-onset hypertension, a higher prevalence of smoking, and greater genetic susceptibility to CAD.[25,26]

Our study underscores the importance of incorporating advanced lipid parameters into routine cardiovascular risk assessment. Given the limitations of LDL-C in capturing residual cardiovascular risk, markers like Lp(a), ApoB/ApoA1 ratio, and sdLDL provide superior predictive value. This is particularly relevant in India, where traditional lipid guidelines may underestimate cardiovascular risk in young individuals [27]. From a therapeutic perspective, targeted interventions such as PCSK9 inhibitors (which lower Lp(a)), lifestyle modifications, and aggressive lipid-lowering strategies should be considered for high-risk individuals.[28] Additionally,

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early screening in individuals with a strong family history of CAD may help in preventing premature cardiovascular events.[29,30]

Limitations

While our study provides compelling evidence, it has certain limitations. The cross-sectional design precludes causal inference, and genetic predisposition to elevated Lp(a) was not assessed. Additionally, longitudinal follow-up studies are needed to establish the prognostic value of these markers in young CAD patients.

CONCLUSION

This study highlights the superior predictive value of advanced lipid parameters in assessing the risk of premature coronary artery disease (CAD) among young Indians. Lipoprotein(a) >30 mg/dL, an ApoB/ApoA1 ratio >0.85, and Small Dense LDL >40 mg/dL emerged as independent risk factors, demonstrating greater diagnostic accuracy than traditional lipid markers. These findings underscore the importance of incorporating advanced lipid profiling into routine cardiovascular risk assessment, particularly in high-risk populations. Given the early onset and aggressive nature of CAD in Indians, timely identification of at-risk individuals using these markers can facilitate early intervention, lifestyle modification, and targeted lipid-lowering therapies. Future longitudinal studies are warranted to evaluate their prognostic value and to refine risk stratification strategies for preventing premature cardiovascular events in young adults.

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