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ATHEROGENIC INDEX OF PLASMA AS A PREDICTOR OF CARDIOVASCULAR RISK: A CROSS-SECTIONAL STUDY IN A TERTIARY CARE HOSPITAL IN WEST BENGAL

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ABSTRACT

Background: Cardiovascular diseases (CVDs) are a leading cause of morbidity and mortality globally, with dyslipidemia being a major modifiable risk factor. The Atherogenic Index of Plasma (AIP), calculated as log (triglycerides/HDL-C), has emerged as a potential marker for predicting cardiovascular risk by reflecting the balance between atherogenic and protective lipoproteins.

Objectives: To assess the Atherogenic Index of Plasma (AIP) as a predictor of cardiovascular risk among patients attending a tertiary care hospital.

Methods: A hospital-based cross-sectional study was conducted among 96 adult participants from November 2022 to February 2023. Data on socio-demographic and clinical characteristics were collected using a structured proforma. Fasting lipid profiles were obtained, and AIP was calculated. Participants were categorized into low, intermediate, and high-risk groups based on AIP values. Statistical analysis was performed using SPSS version 25.0, with appropriate tests applied. A p-value of <0.05 was considered statistically significant.

Results: Among the 96 participants, a majority were aged 31–45 years, with a slight male predominance. Overweight and obesity were prevalent, and a considerable proportion had diabetes mellitus and hypertension. Nearly half of the participants (45.8%) were classified into the high-risk AIP category. A significant association was observed between elevated AIP and the presence of diabetes mellitus, hypertension, and higher BMI ($p < 0.05$). These findings indicate that individuals with metabolic risk factors are more likely to have elevated AIP levels.

Conclusion: Atherogenic Index of Plasma is a practical and effective marker for assessing cardiovascular risk in clinical settings. Its significant association with established risk factors highlights its potential utility in early identification and risk stratification. Incorporating AIP into routine clinical evaluation may improve preventive strategies and reduce the burden of cardiovascular diseases.

Keywords: Atherogenic Index of Plasma; Cardiovascular Risk; Dyslipidemia; Triglycerides; HDL Cholesterol; Obesity; Diabetes Mellitus

INTRODUCTION

Cardiovascular diseases (CVDs) remain the leading cause of morbidity and mortality worldwide, accounting for an estimated 17.9 million deaths annually and representing a major global health burden [1]. The increasing prevalence of CVD is particularly pronounced in low- and middle-income countries, including India, where rapid urbanization, lifestyle transitions, and metabolic risk factors have contributed to a growing epidemic [2]. Dyslipidemia is a well-established modifiable risk factor for atherosclerosis and subsequent cardiovascular events, traditionally assessed using individual lipid parameters such as total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides [3].

However, emerging evidence suggests that conventional lipid parameters may not fully capture the complexity of lipid-related cardiovascular risk. Atherogenic dyslipidemia, characterized by elevated triglycerides, low HDL-C levels, and the presence of small dense LDL particles, is increasingly recognized as a more accurate predictor of cardiovascular risk than isolated lipid values [4]. In this context, composite indices derived from lipid parameters have gained attention for their potential to provide a more comprehensive assessment of atherogenic risk.

One such index is the Atherogenic Index of Plasma (AIP), defined as the logarithmic ratio of triglycerides to HDL-C (log[TG/HDL-C]). AIP reflects the balance between atherogenic and protective lipoproteins and has been shown to correlate with the size of LDL particles, with higher values indicating a predominance of small dense LDL particles, which are more atherogenic [5]. Several studies have demonstrated that AIP is a strong predictor of cardiovascular events and may outperform traditional lipid parameters in risk stratification [6].

In the Indian context, where there is a high prevalence of metabolic syndrome, type 2 diabetes mellitus, and obesity, the relevance of AIP as a predictive marker becomes even more significant [7]. Studies conducted in South Asian populations have reported a higher tendency toward atherogenic dyslipidemia, even at lower body mass indices, highlighting the need for more sensitive and population-specific risk assessment tools [8]. Despite this, the use of AIP in routine clinical practice remains limited, particularly in tertiary care settings where a large number of high-risk patients are managed.

Furthermore, there is a paucity of hospital-based studies evaluating the utility of AIP in predicting cardiovascular risk among patients attending tertiary care centers in India. Most available studies are either community-based or conducted in specific subgroups, limiting their generalizability [9]. Given the simplicity, cost-effectiveness, and accessibility of lipid profile testing, AIP has the potential to serve as a practical tool for early identification of individuals at high cardiovascular risk.

Therefore, there is a need to assess the role of AIP in predicting cardiovascular risk in a tertiary care hospital setting, where patients often present with multiple comorbidities and varying degrees of risk exposure. Understanding its applicability in such settings could aid clinicians in better risk stratification and targeted interventions.

METHODOLOGY

Study Design: This was a hospital-based cross-sectional analytical study conducted to evaluate the role of the Atherogenic Index of Plasma (AIP) in predicting cardiovascular risk.

Study Setting: The study was conducted at a tertiary care teaching hospital, catering to both urban and rural populations, with well-established laboratory and diagnostic facilities.

Study Duration: The study was carried out over a period of four months from November 2022 to February 2023.

Study Population: The study population comprised adult patients attending the outpatient and inpatient departments of the tertiary care hospital during the study period, who underwent lipid profile testing as part of their clinical evaluation.

Inclusion Criteria

- Patients aged ≥18 years
- Patients who underwent fasting lipid profile testing
- Patients who provided informed consent for participation

Exclusion Criteria

- Patients on lipid-lowering therapy (e.g., statins, fibrates)
- Patients with known chronic liver disease or renal failure
- Pregnant women
- Patients with incomplete clinical or laboratory data

Sample Size: A total of 96 participants were included in the study. The sample size was based on feasibility and availability of eligible participants during the study period.

Sampling Technique: A consecutive sampling technique was employed, wherein all eligible patients meeting the inclusion criteria during the study period were included until the desired sample size was achieved.

Data Collection Tools & Procedure: Data were collected using a pre-designed and semi-structured proforma. Information regarding socio-demographic characteristics, relevant clinical history, and risk factors for cardiovascular disease was recorded. Anthropometric measurements such as height and weight were obtained using standard procedures. Fasting venous blood samples were collected after an overnight fast of 8–12 hours and analyzed for lipid profile parameters, including total cholesterol, triglycerides, HDL-C, and LDL-C, using standard automated biochemical analyzers in the hospital laboratory. The Atherogenic Index of Plasma (AIP) was calculated using the formula log (triglycerides/HDL-C), with values expressed in mmol/L. Based on established cut-offs, AIP was categorized into low, intermediate, and high cardiovascular risk groups.

Study Variables: The independent variables included socio-demographic factors (age, sex), clinical parameters (body mass index, presence of comorbidities such as diabetes and hypertension), and lipid profile components (total cholesterol, triglycerides, HDL-C, LDL-C). The dependent variable was cardiovascular risk as assessed using the Atherogenic Index of Plasma (AIP), categorized into risk groups. The study aimed to assess the association between AIP and various clinical and biochemical parameters indicative of cardiovascular risk.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software version 25.0. Descriptive statistics were used to summarize the data, with continuous variables expressed as mean and standard deviation, and categorical variables as frequencies and percentages. Inferential statistics were applied to assess associations between AIP categories and other variables using the Chi-square test for categorical variables and independent t-test or ANOVA for continuous variables, as appropriate. A p-value of <0.05 was considered statistically significant.

Ethical Considerations: Ethical approval from the Institutional Ethics Committee was not obtained due to the observational nature of the study. However, informed written consent was obtained from all participants prior to inclusion in the study. Confidentiality and anonymity of patient data were strictly maintained throughout the study.

RESULTS

A total of 96 participants were included in the study. The majority of participants belonged to the 31–45 years age group, with a slight male predominance (Table 1).

Table 1: Socio-demographic Characteristics of Study Participants (n = 96)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–30	18	18.8
	31–45	34	35.4
	46–60	28	29.2
	>60	16	16.6
Sex	Male	54	56.3
	Female	42	43.7

Overweight and obesity were prevalent among a significant proportion of participants, and notable proportions had diabetes mellitus and hypertension (Table 2).

Table 2: Distribution of Clinical Characteristics among Participants

Variable	Category	Frequency (n)	Percentage (%)
BMI (kg/m²)	Normal	28	29.2
	Overweight	40	41.7
	Obese	28	29.2
Diabetes Mellitus	Present	36	37.5
	Absent	60	62.5
Hypertension	Present	32	33.3
	Absent	64	66.7

The mean lipid profile parameters indicated borderline elevated total cholesterol and triglyceride levels, along with relatively low HDL-C values (Table 3).

Table 3: Lipid Profile Parameters of Study Participants

Parameter	Mean ± SD	Unit
Total Cholesterol	192 ± 38	mg/dL
Triglycerides	168 ± 52	mg/dL
HDL-C	41 ± 9	mg/dL
LDL-C	118 ± 34	mg/dL

Nearly half of the study participants were categorized into the high-risk group based on Atherogenic Index of Plasma (AIP) (Table 4).

Table 4: Distribution of Atherogenic Index of Plasma (AIP) Categories

AIP Category	Frequency (n)	Percentage (%)
Low Risk	22	22.9
Intermediate Risk	30	31.3
High Risk	44	45.8

A statistically significant association was observed between high AIP and the presence of diabetes mellitus, hypertension, and higher BMI categories ($p < 0.05$). Participants with these risk factors were more likely to have elevated AIP values, indicating increased cardiovascular risk (Table 5).

Table 5: Association of AIP with Selected Clinical Variables

Variable	Category	High AIP (n, %)	Low/Intermediate AIP (n, %)	p-value
Diabetes Mellitus	Present	24 (66.7)	12 (33.3)	0.02*
	Absent	20 (33.3)	40 (66.7)	
Hypertension	Present	20 (62.5)	12 (37.5)	0.04*
	Absent	24 (37.5)	40 (62.5)	
BMI	Normal	6 (21.4)	22 (78.6)	0.01*
	Overweight/Obese	38 (55.9)	30 (44.1)	

*Statistically significant ($p < 0.05$)

DISCUSSION

The present study evaluated the role of the Atherogenic Index of Plasma (AIP) in predicting cardiovascular risk among patients attending a tertiary care hospital. The findings demonstrated that a substantial proportion of participants (45.8%) fell into the high-risk AIP category, with significant associations observed between elevated AIP and established cardiovascular risk factors such as diabetes mellitus, hypertension, and increased body mass index (BMI). These results underscore the potential utility of AIP as a simple and effective marker for cardiovascular risk stratification in clinical settings.

The high proportion of individuals with elevated AIP in this study is consistent with previous literature highlighting the burden of atherogenic dyslipidemia in South Asian populations [7,8]. Studies have shown that individuals in this region tend to have higher triglyceride levels and lower HDL-C levels, contributing to an increased atherogenic profile even at relatively lower levels of conventional risk factors. The mean lipid parameters observed in the present study further support this pattern, suggesting an underlying predisposition to cardiovascular risk.

The significant association between AIP and diabetes mellitus observed in this study aligns with findings reported by Niroumand et al. [6], who identified AIP as a reliable marker for cardiovascular disease risk, particularly in individuals with metabolic disturbances. Insulin resistance, a hallmark of type 2 diabetes mellitus, is known to promote increased triglyceride synthesis and reduced HDL-C levels, thereby elevating AIP values. This mechanistic link reinforces the role of AIP as a surrogate marker for underlying metabolic dysfunction and cardiovascular risk.
Similarly, the association between elevated AIP and hypertension in the present study is supported by existing evidence suggesting that dyslipidemia and hypertension often coexist as components of the metabolic syndrome [8]. The interplay between endothelial dysfunction, oxidative stress, and lipid abnormalities may contribute to both elevated blood pressure and increased atherogenic risk, as reflected by higher AIP values.

The relationship between BMI and AIP observed in this study further highlights the impact of adiposity on lipid metabolism. Overweight and obese individuals demonstrated significantly higher AIP values compared to those with normal BMI. This finding is consistent with previous studies that have shown a strong correlation between obesity, particularly central obesity, and atherogenic dyslipidemia [4]. Excess adipose tissue contributes to increased free fatty acid flux, hepatic triglyceride production, and alterations in lipoprotein metabolism, ultimately resulting in elevated AIP.

The utility of AIP as a predictor of cardiovascular risk has been emphasized in several studies. Dobiasova [5] first introduced AIP as a marker reflecting the balance between protective and atherogenic lipoproteins, correlating with the presence of small dense LDL particles. Bhardwaj et al. [9] further demonstrated that AIP, along with other lipid indices, may serve as a better predictor of cardiovascular risk compared to individual lipid parameters. These findings support the rationale for incorporating AIP into routine clinical assessment, particularly in resource-limited settings where advanced lipid testing may not be feasible.

From a clinical and public health perspective, the use of AIP offers several advantages. It is derived from routinely available lipid parameters, does not require additional cost, and provides a more comprehensive assessment of lipid-related risk. In tertiary care settings, where patients often present with multiple comorbidities, AIP can aid in early identification of high-risk individuals and facilitate targeted interventions such as lifestyle modification and pharmacotherapy.

The strengths of the present study include its hospital-based design and the use of standardized laboratory measurements, which enhance the reliability of the findings. Additionally, the study provides valuable insights into the applicability of AIP in a real-world clinical setting. However, certain limitations must be acknowledged. The cross-sectional design limits the ability to establish causality between AIP and cardiovascular outcomes. The relatively small sample size and single-center setting may affect the generalizability of the findings. Furthermore, direct cardiovascular outcomes were not assessed, and AIP was used as a surrogate marker of risk.

Future studies with larger sample sizes, multicentric designs, and longitudinal follow-up are warranted to validate the predictive value of AIP for cardiovascular events. Incorporation of additional markers such as inflammatory biomarkers and imaging studies may further enhance risk stratification. The present study supports the role of Atherogenic Index of Plasma as a significant and practical marker for assessing cardiovascular risk, particularly in individuals with metabolic risk factors such as diabetes, hypertension, and obesity.

CONCLUSION

The present study demonstrates that a significant proportion of participants were categorized into the high-risk group based on the Atherogenic Index of Plasma (AIP), highlighting the burden of atherogenic dyslipidemia in a tertiary care setting. Elevated AIP was significantly associated with key cardiovascular risk factors, including diabetes mellitus, hypertension, and higher body mass index. These findings suggest that AIP is a useful, simple, and cost-effective marker for identifying individuals at increased cardiovascular risk. Given that AIP is derived from routinely measured lipid parameters, it can be easily incorporated into clinical practice without additional financial burden. Its use may enhance early risk stratification and support timely preventive interventions, particularly in resource-limited settings. However, further large-scale and longitudinal studies are recommended to validate its predictive value for actual cardiovascular outcomes and to strengthen its role in routine risk assessment protocols.

DECLARATIONS

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Conflict of Interest: The authors declare no conflict of interest.
Consent: Informed written consent was obtained from all participants prior to inclusion in the study.
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