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Fasting lipid profile and atherogenic indices among HIV patients at Alex-Ekwueme university teaching hospital Abakaliki, Ebonyi State, Nigeria

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Abstract

Antiretroviral therapy (ART) has significantly improved survival among individuals living with Human Immunodeficiency Virus (HIV). This is a case-control, cross-sectional study, designed to determine fasting lipid profile and atherogenic indices among HIV-positive patients on ART. A total of 120 participants were recruited, comprising 60 HIV-positive adults on ART and 60 age- and sex-matched HIV-negative controls. Total cholesterol (TC), triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C) were estimated using colorimetric methods, LDL-C was calculated using the Friedewald formula. Atherogenic indices (AI): Atherogenic Index of Plasma (AIP), Castelli Risk Index-I (CRI-I), and Castelli Risk Index-II (CRI-II) were derived from lipid parameters. Results showed significantly higher triglyceride levels (1.68 ± 0.22 mmol/L vs. 1.22 ± 0.31 mmol/L; p< 0.001) and lower HDL-C levels (1.08 ± 0.13 mmol/L vs. 1.45 ± 0.24 mmol/L; p<0.001) among HIV-positive participants compared to controls. Total cholesterol and LDL-C were significantly lower in HIV-positive subjects (p<0.001). AI showed high levels of CRI-II and AIP in the HIV-positive compared to control. All the AI showed a negative correlation with HDL, and AIP showed a positive correlation with TG (p< 0.001). This study showed that HIV patients on ART exhibit dyslipidemia that is not obvious using routine lipid parameters which may expose the patients to atherogenic risk.

Keywords: HIV; Antiretroviral Therapy; Dyslipidaemia; Atherogenic Indices; Cardiovascular Risk

1. Introduction

The Human Immunodeficiency Virus (HIV) remains a global public health challenge, affecting approximately 40.8 million people worldwide in 2024, with the highest burden occurring in low- and middle-income countries, particularly in sub-Saharan Africa [1]. HIV primarily attacks the immune system by targeting cluster of differentiation 4 (CD4) cells, thereby weakening the body's defense against infections and increases susceptibility to acquired immunodeficiency syndrome (AIDS) in the absence of treatment [2]. The advent of antiretroviral therapy (ART) has significantly transformed HIV infection from a fatal disease into a manageable chronic condition, leading to remarkable improvements in survival and quality of life among infected individuals [3]. However, prolonged survival among HIV patients has been accompanied by emerging health challenges, particularly an increased risk of cardiovascular diseases (CVDs) associated with chronic inflammation, metabolic abnormalities, and adverse effects of ART [4].

Lipids, including cholesterol and triglycerides, are essential components of normal cellular and metabolic processes. Nevertheless, abnormalities in lipid metabolism can predispose individuals to serious cardiovascular complications such as atherosclerosis, myocardial infarction, and stroke [5]. Dyslipidemia is frequently observed among HIV-infected individuals and is characterized by elevated triglycerides, increased low-density lipoprotein cholesterol (LDL-C), and reduced high-density lipoprotein cholesterol (HDL-C) levels [6]. These lipid abnormalities may result from persistent immune activation caused by HIV infection as well as the metabolic effects of certain antiretroviral drugs, particularly

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protease inhibitors, which alter hepatic lipid metabolism and fat distribution [7]. Consequently, cardiovascular disease has emerged as a leading cause of morbidity and mortality among people living with HIV [4].

In recent years, atherogenic indices derived from lipid ratios have gained attention as more reliable predictors of cardiovascular risk than individual lipid parameters alone [8]. These indices include the Atherogenic Index of Plasma (AIP), Castelli Risk Index I and II, and Atherogenic Coefficient, which are calculated using lipid profile components such as triglycerides, total cholesterol, LDL-C, and HDL-C [9]. Atherogenic indices provide valuable insight into the chances that arterial plaque will form in the body and the development of atherosclerosis. Studies have demonstrated that these indices are particularly useful in HIV patients because conventional lipid parameters may underestimate cardiovascular risk due to the complex metabolic disturbances associated with HIV infection and ART [10]. Okonkwo *et al*., (2024) [11] showed that an elevated AIP is strongly associated with increased risk of atherosclerosis and cardiovascular complications among HIV-positive individuals

In Nigeria, HIV prevalence remains a significant public health concern, with approximately 1.4% of the adult population affected [12]. Alongside the burden of HIV, the incidence of cardiovascular disease among HIV patients is increasing [13]. This trend is further aggravated by lifestyle-related risk factors such as unhealthy diet, physical inactivity, alcohol consumption, and smoking, which are common in many Nigerian communities. Globally, the increasing burden of non-communicable diseases among HIV patients highlights the importance of investigating lipid metabolism and cardiovascular risk markers in this population [14]. In sub-Saharan Africa, where access to advanced cardiovascular diagnostic tools may be limited, simple and cost-effective assessments such as fasting lipid profile evaluation and atherogenic indices could serve as valuable tools for early identification and management of cardiovascular risk [15]. Hence, assessing lipid profiles and atherogenic indices among HIV patients is essential for understanding the extent of cardiovascular risk within this population.

2. Materials and methods

2.1. Study Design/ Study Population

This is case-control, cross-sectional study, designed to evaluate lipid profile: total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) among HIV-positive individuals on antiretroviral therapy (ART). A total number of 60 HIV-positive participants aged between18–60 years were randomly recruited from Alex Ekwueme Federal University Teaching Hospital and they served as the test group. Additionally, 60 apparently healthy age and sex-matched HIV-negative individuals were also, randomly recruited from the same community and they served as the control group.

2.2. Inclusion and Exclusion Criteria

Only HIV-positive participants aged 18–60 years who had been on antiretroviral therapy (ART) for at least 12 consecutive months were recruited for this study. Participants with a history of hypertension, renal insufficiency, liver disease, intestinal ulceration, or diabetes mellitus were excluded from the study. Pregnant women and lactating mothers were also excluded. In addition, participants receiving medications other than ART, including lipid-lowering drugs, dietary supplements, or herbal extracts, were not eligible for inclusion in the study.

2.3. Laboratory Analysis

Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) were estimated using enzymatic colorimetric methods as described by Allain *et al*. (1974), Warnick *et al*. (1982) and Bucolo and David (1973) [16,17,18] respectively. Low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula as described by (Friedewald *et al*. 1972).

Atherogenic indices were calculated according to the method described by Dobiášová and Frohlich (2001)

- Atherogenic Index of Plasma (AIP) = $\log_{10}$ (TG/HDL-C)
- Castelli Risk Index I (CRI-I) = TC/HDL-C
- Castelli Risk Index II (CRI-II) = LDL-C/HDL-C

2.4. Ethical Considerations

Ethical approval was obtained from the Ethics committee of Alex Ekwueme Federal University Teaching Hospital Abakaliki (AE-FUTHA/REC/vol.3/2026/629). All participants provided their informed consent after receiving a clear explanation of the study's purpose, procedures, and potential risks in simple language. Participation was voluntarily, and individuals were given option to withdraw at any time without penalty. Confidentiality was maintained throughout the study period.

2.5. Data Analysis Techniques

Data was analyzed using SPSS software version 22. Independent t-test compared lipid profiles and atherogenic indices between HIV patients and controls. Pearson correlation analysis was used to determine the relationships between different cholesterol and atherogenic indices among the test group. Results with a p-value less than 0.05 were considered significant.

3. Results

Table 1: Plasma Total Cholesterol, Triglycerides, HDL-Cholesterol, and LDL-Cholesterol in HIV Patients and Comparison with Controls

The mean TC was significantly lower in the HIV-positive group ($p<0.001$), while TG was markedly higher ($p<0.001$). HDL-C and LDL-C were lower in HIV-positive participants than the HIV-negative control and when compared between the groups were statistically significant ($p <0.001$).

Table 1 Fasting Lipid Profile in HIV-Positive and HIV-Negative Participants

Parameter	Test (n=60)	Control (n=60)	t-value	p-value
TC (mmol/L)	3.10 ± 0.33	4.18 ± 0.51	7.85	<0.001
TG (mmol/L)	1.68 ± 0.22	1.22 ± 0.31	5.12	<0.001
HDL (mmol/L)	1.08 ± 0.13	1.45 ± 0.24	5.68	<0.001
LDL (mmol/L)	1.18 ± 0.34	2.41 ± 0.48	8.21	<0.001

Key: TC = Total Cholesterol; TG = Triglycerides; HDL = High-Density Lipoprotein Cholesterol; LDL = Low-Density Lipoprotein Cholesterol, Test=HIV positive, Control= HIV negative

Table 2 Atherogenic Indices (Castelli Risk Index-I, Castelli Risk Index-II, and Atherogenic Index of Plasma) in HIV Patients and Comparison with Controls

The atherogenic indices showed varying patterns between the groups. Castelli Risk Index-I (CRI-I) was comparable in both groups with no significant difference ($p = 0.830$). Castelli Risk Index-II (CRI-II) and Atherogenic Index of Plasma (AIP) were significantly higher in the HIV-positive participants ($p<0.001$).

Table 2 Atherogenic Indices in HIV-Positive and HIV-Negative Participants

Index	HIV-Positive (n=60)	HIV-Negative (n=60)	t-value	p-value
CRI-I	2.95 ± 0.41	2.91 ± 0.52	0.22	0.830
CRI-II	1.69 ± 0.41	1.10 ± 0.35	5.42	<0.001
AIP	0.19 ± 0.10	0.08 ± 0.04	6.89	<0.001

Key: CRI-I = Castelli Risk Index-I (TC/HDL); CRI-II = Castelli Risk Index-II (LDL/HDL); AIP = Atherogenic Index of Plasma [$\log_{10}$(TG/HDL)].

Table 3-5: Determination of the Relationship Between Atherogenic Indices and Fasting Lipid Profiles in HIV Patients

Pearson correlation between atherogenic indices (AIP, CRI-I, and CRI-II) and individual lipoproteins showed a strong positive correlation between AIP and TG ($r = 0.801$, $p < 0.001$), and a negative correlation with HDL ($r = -0.714$, $p < 0.001$). No significant correlations were observed between AIP with TC and LDL. CRI-I showed a negative correlation

with HDL (r = –0.523, p = 0.045) and no significant correlations with other lipids (table 4). CRI-II showed a negative correlation with HDL (r = –0.612, p = 0.015) (see table 5).

Table 3 Pearson Correlation of AIP with Lipid Parameters (HIV-Positive Participants, n=60)

Variable	Correlation coefficient (r) with AIP	p-value
TG	0.801	<0.001
HDL	–0.714	<0.001
TC	0.089	0.750
LDL	–0.112	0.690

Key: AIP = Atherogenic Index of Plasma; TC = Total Cholesterol; TG = Triglycerides; HDL = High-Density Lipoprotein Cholesterol; LDL = Low-Density Lipoprotein Cholesterol (calculated). P < 0.05 indicates statistical significance.

Table 4 Pearson Correlation of CRI-I with Lipid Parameters (HIV-Positive Participants, n=60)

Variable	Correlation coefficient (r) with CRI-I	p-value
TG	0.312	0.258
HDL	–0.523	0.045
TC	0.456	0.089
LDL	0.278	0.318

Table 5 Pearson Correlation of CRI-II with Lipid Parameters (HIV-Positive Participants)

Variable	Correlation coefficient (r) with CRI-II	p-value
TG	0.189	0.501
HDL	–0.612	0.015
TC	0.345	0.208
LDL	0.412	0.128

Key: CRI-I and II = Castelli Risk Index-I, II (LDL/HDL); TC = Total Cholesterol; TG = Triglycerides; HDL = High-Density Lipoprotein Cholesterol; LDL = Low-Density Lipoprotein Cholesterol.

4. Discussion

This study evaluated fasting lipid profile and atherogenic indices in HIV-positive patients on antiretroviral therapy (ART). Triglyceride, was significantly increased in the HIV-positive patient compared to HIV-negative control group while total cholesterol, low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) were significantly lower in HIV-positive patient compared to the control group. More so, the Atherogenic Index of Plasma (AIP) and CRI-II were increased among HIV-positive subjects, indicating elevated cardiovascular risk despite relatively low TC and LDL-C levels. However, there was no difference in the CRI-I observed between the HIV-positive and the HIV-negative group. The alterations observed in this study may be attributed to either the activities of the HIV virus which is characterized by chronic immune activation and HIV induced inflammation or the effect of anti-retro viral drug (ART), or the combined effect of both the human immunodeficiency virus and anti-retro viral drug on the HIV-positive patient.

These findings align with several studies in sub-Saharan Africa and Nigeria. Fiseha *et al*. (2021) in Ethiopia and Kigongo *et al*., (2024)[21,7] in Uganda reported similar findings. Okunorobo *et al*. (2023) and Ohunene *et al*., (2023)[22,23] reported increased triglyceride in HIV-positive patients on ART. Daniyan and Iroezindu (2013)[24] and Sigh *et al*., (2014)[25],

reported increased total cholesterol. We observed low total cholesterol in HIV-positive patients, contrary to high total cholesterol reported by Okunorobo *et al*., (2023) [22]. The difference may be accrued to ethno-genetic variation between the study population, difference in treatment regime or due to difference in the study criteria, while we used as least 12-months on ART, they used 24 months as the cut-off duration on ART to participate in their study. However, high prevalence of dyslipidaemia has been associated with prolonged ART [26].

Furthermore, we observed elevated CRI-I and CRI-II in the HIV-positive participants compared to control group. This reflects the hidden cardiovascular risk among the test HIV-positive patient on ART despite low TC and LDL levels and underscores the superiority of ratio-based indices over individual lipid parameters as a predictor of cardiovascular risk in HIV populations. Aleruchi Didia *et al*., (2020) and Assumtor *et al*., (2025) [27,28] reported increased CRI-I and CRI-II and HIV infected patients on ART. In our study, there was no difference in the levels of AIP between the HIV-positive and HIV-negative group. Bhardwaj *et al*., (2023) [29] reported a non-significant increase in CRI-I between HIV-positive and HIV-negative patients. Some other studies have reported no statistical difference in Total cholesterol, TG, LDL-C, and HCL-C between the HIV positive patients and HIV-negative control group while, the atherogenic indices including CRI-I and CRI-II were significantly increased in the same HIV-positive group [29,30,31]. The variations on the different studies may be attributed to ethno-genetic variations in the study groups, different regime of ART or intrinsic factors that are related to lipid metabolism.

Although, there were no relationship recorded between the CRI-I, CRI-II and lipid profile parameters but, AIP showed a positive correlation and negative correlation with TG and HDL respectively. This is suggestive that AIP could be a better predictor of cardiovascular risk when compared with CRI-I and CRI-II. However, in 1999, Grove *et al*[32] reported that CRI-I or CRI-II is the best predictor of cardiovascular risk. Further studies have continued to show a different model ever since, Da Luz *et al*., [33] (2008) highlighted the role of AIP in predicting CVD risk and effectiveness in the management of CVD. Other studies, have suggested that where markers of lipid profile may appear within the reference range, AIP may play a diagnostic alternative, Nwogha *et al*., [34] and Dobioasova *et al*., [31] reported a strong correlation between AIP and coronary heart disease

5. Conclusion

These findings revealed latent atherogenic risk among HIV-positive patients on ART that was not evident from lipid profile alone. They were significant correlations observed between lipid parameters and atherogenic indices, highlights the need to routinely incorporate atherogenic indices into HIV care for early cardiovascular risk detection.

Recommendations

Following these alterations, we therefore recommend that the calculation of atherogenic indices be included as a routine protocol in HIV clinics for early detection and monitoring of cardiovascular risk

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this research.

Statement of informed consent

Written informed consent was obtained from all individual participants prior to their inclusion in the study

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