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A study on echocardiographic and electrocardiographic findings in HIV-infected patients and their correlation with CD4 counts

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Abstract

Background: Human Immunodeficiency Virus (HIV) infection is linked to a range of cardiovascular complications including cardiomyopathy, pericardial disease, pulmonary hypertension, and coronary artery disease whether or not patients receive antiretroviral therapy (ART). The degree of immune suppression, measured by CD4 cell count, is a critical predictor of cardiovascular involvement in people living with HIV (PLHIV).

Objective: To assess the prevalence and types of electrocardiographic (ECG) and echocardiographic (ECHO) abnormalities in HIV-positive patients, and to determine their correlation with CD4 cell counts.

Methods: This hospital-based observational study included HIV-positive patients on ART. Each participant underwent clinical evaluation, ECG, 2D ECHO, and CD4 cell count testing. The prevalence of cardiac abnormalities and their relationship to CD4 levels were analyzed statistically (SPSS). Echocardiographic findings evaluated included diastolic dysfunction, systolic dysfunction, pericardial effusion, and pulmonary hypertension.

Results: Significant cardiovascular abnormalities were most frequent in patients with CD4 counts below 200 cells/μL. ECG changes included sinus tachycardia, QT prolongation, and repolarization abnormalities. ECHO revealed a high incidence of diastolic dysfunction, reduced ejection fraction, and pericardial effusions. A statistically significant association was found between lower CD4 counts and greater cardiovascular involvement, suggesting advanced immunosuppression accelerates cardiac dysfunction in HIV.

Conclusion: HIV-infected individuals face elevated risk of cardiovascular abnormalities, particularly as CD4 counts decline. Routine cardiovascular screening with ECG and ECHO—especially for those with low CD4 levels—is advised to enable early detection and management, thereby reducing morbidity and mortality among PLHIV.

Keywords: HIV; CD4 Cell Count; Echocardiography; Electrocardiography; Cardiomyopathy; Cardiovascular Disease

1. Introduction

Human immunodeficiency virus (HIV)/AIDS remains a major global health challenge, with 38 million people living with HIV worldwide as of 2019 and a disproportionate impact in developing and resource-limited countries.[1–3] HIV primarily targets CD4+ T cells, establishing infection in mucosal tissues before systemic spread. The virus rapidly replicates in the initial weeks, leading to a progressive decline in CD4 count and eventual immunodeficiency over several years, although disease progression can vary widely among individuals.[4–7] A CD4 count below 200 cells/μL marks the threshold for acquired immunodeficiency syndrome (AIDS), and response to highly active antiretroviral therapy (HAART) is best tracked by CD4 recovery.[8]

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With HAART prolonging survival, cardiovascular diseases (CVDs) have emerged as a leading cause of morbidity and mortality among people living with HIV/AIDS (PLHIV).[9]–[10] Cardiovascular complications such as cardiomyopathy, pericardial disease, pulmonary hypertension, and coronary artery disease are more common and tend to present earlier in HIV-infected populations.[10]–[12]AIDS-associated cardiomyopathy, in particular, is linked to advanced immunosuppression (CD4 <100/μL) and carries a poor prognosis.[11]–[12]

Echocardiography is a key imaging tool for assessing cardiac structure and function, and studies in HIV patients have demonstrated a high prevalence of left ventricular dysfunction, cardiomyopathy, pulmonary hypertension, pericardial effusion, and valvular disease. Many of these are attributed to direct viral effects, chronic inflammation, and opportunistic infections. Electrocardiography (ECG) is indispensable for detecting electrical conduction abnormalities, arrhythmias, and ischemic changes, which may be aggravated by ART-associated metabolic disturbances.

The degree of immune suppression, as reflected by CD4 count, is a critical determinant of cardiovascular risk in HIV patients, with lower CD4 counts associated with a higher frequency of cardiac dysfunction, pericardial effusion, and arrhythmias. Early recognition of cardiac involvement and correlation with CD4 status is therefore essential for prognosis and management. [13]

The present study aims to investigate the prevalence and clinical significance of electrocardiographic and echocardiographic abnormalities in HIV-positive patients, compare the diagnostic efficacy of echocardiography versus electrocardiography in detecting cardiac abnormalities, and determine the correlation between these abnormalities and CD4 cell counts.

2. Methodology

This cross-sectional prospective study was conducted over 18 months (July 2023 to December 2024) at Al-Ameen Medical College Hospital, Vijayapura, Karnataka. The study included adult patients (>18 years) with confirmed HIV infection attending the outpatient and inpatient departments of the medicine department. Inclusion criteria required confirmed HIV status and willingness to participate, while patients with structural heart disease, systemic hypertension, diabetes mellitus, thyroid disorders, dyslipidemia, or poor echocardiographic windows were excluded.

All enrolled patients underwent a detailed evaluation, including history, clinical examination, and assessment of vital signs. Systemic examinations encompassed cardiac, respiratory, abdominal, and neurological systems. Laboratory investigations included complete blood count, fasting glucose, renal and liver function tests, lipid profile, and thyroid function tests. Each patient underwent electrocardiography (ECG) to assess for arrhythmias and conduction abnormalities, as well as two-dimensional echocardiography (ECHO) to evaluate cardiac structure and function.

Data were recorded using a structured proforma and analyzed using SPSS version 26. Descriptive statistics were used to summarize the data, with qualitative variables expressed as frequencies and percentages, and quantitative variables as mean and standard deviation. Proportions were compared using the chi-square test, while mean values were compared using the Student's t-test and ANOVA. A p-value of less than 0.05 was considered statistically significant.

3. Results

The demographic profile of the study cohort indicates a predominantly middle-aged population, with the largest proportion (40%) of participants in the 40–49-year age group and a mean age of 43.3 ± 9.46 years. Males constituted the majority, accounting for 78% of the sample, reflecting the known gender distribution of HIV in many regions. Most participants (81%) were receiving antiretroviral therapy (ART), suggesting good access to HIV care and ongoing management. The mean body mass index (BMI) was 23.5 ± 4.3 kg/m^2, with a range extending from underweight to overweight, highlighting nutritional diversity within the group. The median duration of HIV infection was 10 years (IQR: 8–13), indicating a cohort with substantial chronic disease experience and likely prolonged exposure to ART.

The mean ejection fraction (EF) among the study participants was 57.5% (SD ±8.57), indicating that the majority of HIV-positive patients in this cohort had preserved left ventricular systolic function. This finding suggests that overt systolic dysfunction was relatively uncommon in the sample. Correlation analysis revealed a moderate, statistically significant positive association between ejection fraction and CD4 count (Pearson correlation coefficient = 0.395, p = 0.001). This indicates that patients with higher CD4 counts tended to have better left ventricular systolic function. The result highlights the impact of immune status on cardiac function, supporting the hypothesis that greater immunosuppression is associated with increased cardiovascular risk and dysfunction in people living with HIV.

CD4 count categorization reveals that nearly half of the participants (46%) have counts above 350 cells/mm^3, suggesting relatively strong immune function. A smaller percentage falls into the severely immunocompromised categories: 7% have CD4 <50, 31% have 50–199, and 16% have 200–349. The mean CD4 count is 336.8±229.1. (Figure 1)

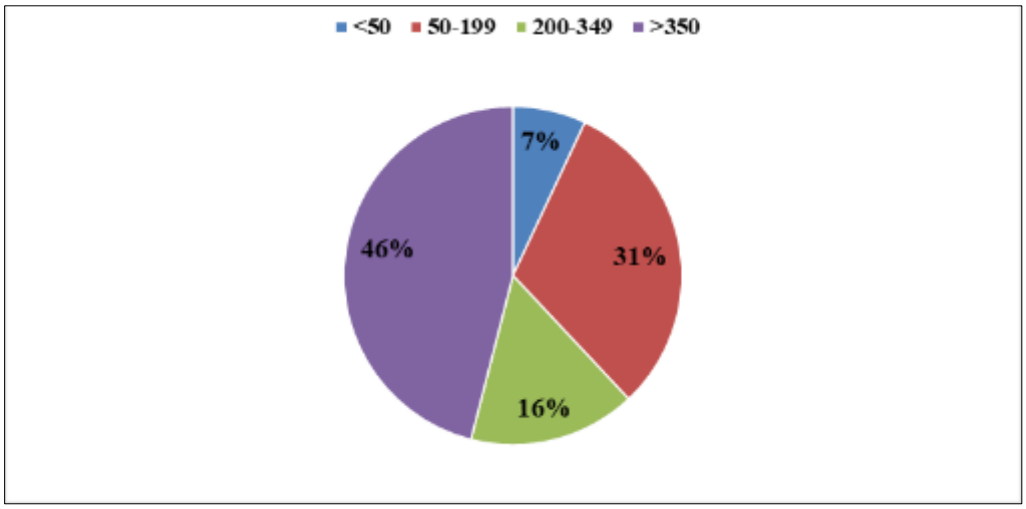

Figure 1 CD4 Category

Stratified EF averages by CD4 category support this: patients with CD4 <50 had a mean EF of 41%, while those with CD4 >350 had an EF of 61.09%, suggesting a graded relationship between immunologic and cardiac function.

Assessment of cardiac function and structure in the study cohort revealed diverse abnormalities. Diastolic function evaluation showed that while 60% of participants had normal LVDD grades, a substantial proportion (40%) demonstrated varying degrees of diastolic dysfunction, with 21% classified as Grade 1, 14% as Grade 2, and 5% as Grade 3.

Electrocardiographic analysis identified sinus tachycardia as the most common abnormality (30%), followed by low voltage complexes (11%), left axis deviation (4%), ST changes (3%), conduction block changes (2%), and right axis deviation (1%). These findings reflect both direct HIV-related cardiac involvement and the influence of associated comorbidities or treatment effects.

Table 1 Baseline Characteristics of Study Participants (N = 100)

Characteristic	Category/Range	Frequency (n)	Percentage (%)
Age Group (years)	20–29	8	8
	30–39	22	22
	40–49	40	40
	50–59	30	30
Gender	Male	78	78
	Female	22	22
ART Status	On ART	81	81
	Not on ART	19	19
BMI (kg/m^2)	Mean ± SD / Median (IQR)	23.5 ± 4.3 / 22.95 (20.7–26.3)	
HIV Duration (years)	Mean ± SD / Median (IQR)	10.3 ± 4.16 / 10 (8–13)	

On echocardiography, reduced left ventricular ejection fraction was present in 30% of patients, indicating significant systolic dysfunction within the cohort. Other notable findings included pericardial effusion (20%), dilated cardiomyopathy (15%), diastolic dysfunction (40%), pulmonary hypertension (10%), and regional wall motion abnormalities (1%). The spectrum of structural and functional cardiac changes observed underscores the importance of routine cardiac evaluation in people living with HIV, particularly as many of these abnormalities may be clinically silent yet prognostically significant.

Table 2 Cardiac Abnormalities: LVDD Grade, ECG, and 2D ECHO Findings (N = 100)

Parameter	Category/Finding	Frequency (n)	Percentage (%)
LVDD Grade	Normal	60	60
	Grade 1	21	21
	Grade 2	14	14
	Grade 3	5	5
ECG	Sinus Tachycardia	30	30
	Low Voltage Complex	11	11
	Left Axis Deviation	4	4
	Right Axis Deviation	1	1
	ST Changes	3	3
	Conduction Block Changes	2	2
2D ECHO	Diastolic Dysfunction	40	40
	Reduced LVEF	30	30
	Pericardial Effusion	20	20
	Dilated Cardiomyopathy	15	15
	Pulmonary Hypertension	10	10
	RWMA	1	1

Table 3 Association of Cardiac Abnormalities with CD4 Category (N=100)

Cardiac Parameter	Subgroup	CD4 <50 (n=7)	CD4 50–199 (n=31)	CD4 200–349 (n=16)	CD4 >350 (n=46)	P Value
LVDD Grade	Normal	0 (0.0%)	4 (12.9%)	14 (87.5%)	44 (95.7%)	0.029
	Grade 1	0 (0.0%)	12 (38.7%)	2 (12.5%)	2 (4.3%)	
	Grade 2	2 (28.6%)	15 (48.4%)	0 (0.0%)	0 (0.0%)	
	Grade 3	5 (71.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
ECG	Sinus Tachycardia	4 (57.1%)	14 (45.2%)	6 (37.5%)	6 (13.0%)	0.207
	Low Voltage Complex	4 (57.1%)	2 (6.5%)	1 (6.3%)	0 (0.0%)	0.296
	Left Axis Deviation	3 (42.9%)	1 (3.2%)	0 (0.0%)	0 (0.0%)	0.622
	Conduction Block Changes	1 (14.3%)	1 (3.2%)	0 (0.0%)	0 (0.0%)	0.075
	ST Changes	3 (42.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.076
2D ECHO	Diastolic Dysfunction	4 (57.1%)	4 (12.9%)	3 (18.8%)	2 (4.3%)	0.021

	Reduced LVEF	6 (85.7%)	12 (38.7%)	6 (37.5%)	6 (13.0%)	0.012
	Pericardial Effusion	2 (28.6%)	10 (32.3%)	6 (37.5%)	2 (4.3%)	0.030
	Dilated Cardiomyopathy	1 (14.3%)	3 (9.7%)	5 (31.3%)	6 (13.0%)	0.442
	Pulmonary Hypertension	1 (14.3%)	2 (6.5%)	4 (25.0%)	3 (6.5%)	0.041
	RWMA	1 (14.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.756

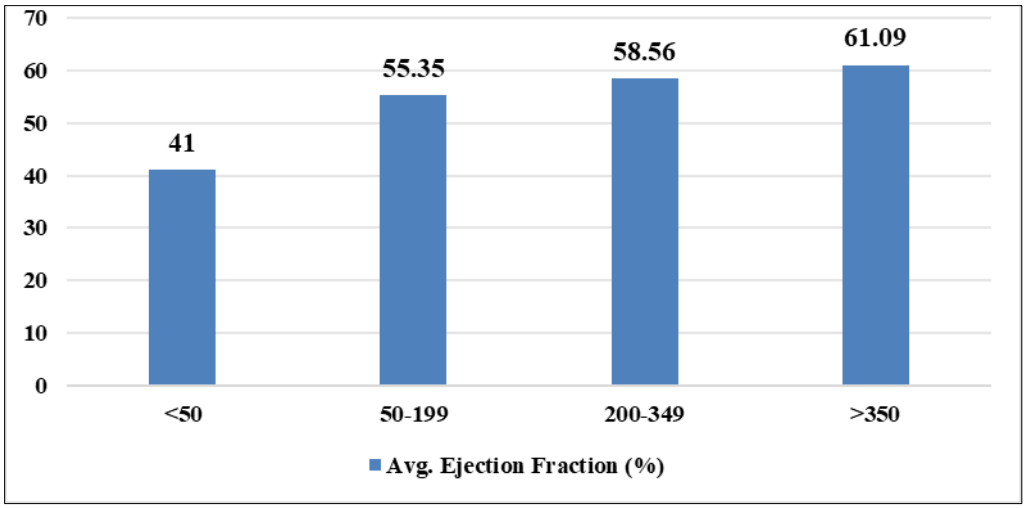

Figure 2 CD4 Count vs Average Ejection Fraction (%)

3.1. Association Between Cardiac Abnormalities and CD4 Category

3.1.1. Left Ventricular Diastolic Dysfunction (LVDD) and CD4 Count

The association between LVDD grade and CD4 cell count categories demonstrated a statistically significant relationship ($p = 0.029$). In the most severely immunocompromised group (CD4 <50), 71.4% had Grade 3 (severe) diastolic dysfunction and 28.6% had Grade 2 dysfunction, indicating that all patients in this group were affected by advanced LVDD. Among those with CD4 counts 50–199, 12.9% exhibited normal diastolic function, while 38.7% had Grade 1 and 48.4% had Grade 2 dysfunction. A marked improvement was seen in the 200–349 CD4 group, with 87.5% showing normal diastolic function and only 12.5% exhibiting Grade 1 dysfunction. Notably, even in the CD4 >350 group, 4.3% had diastolic dysfunction while the majority (95.7%) had normal function. These findings underscore that progressive immunosuppression is closely associated with worsening diastolic cardiac performance, and that immune recovery appears to protect against LVDD.

3.1.2. Electrocardiographic (ECG) Abnormalities and CD4 Category

While no ECG abnormality reached statistical significance across CD4 strata, several clinically relevant patterns emerged. Sinus tachycardia was most prevalent among those with CD4 <50 (57.1%) and steadily declined with increasing CD4 counts, to just 13% in those with CD4 >350 ($p = 0.207$). Low voltage complexes and left axis deviation were also most frequent in the lowest CD4 group, further suggesting a possible relationship between profound immune suppression and cardiac electrical disturbances, even though these trends did not achieve statistical significance. Notably, conduction block changes and ST changes were observed only in the lowest CD4 categories. While these findings do not meet conventional thresholds for statistical significance, the observed trends highlight the possibility that advanced immunosuppression is associated with an increased risk of arrhythmias and conduction abnormalities.

3.1.3. Echocardiographic (2D ECHO) Findings and CD4 Category

A clear and statistically significant association was found between CD4 category and several key echocardiographic abnormalities. Reduced left ventricular ejection fraction (LVEF) was seen in 85.7% of patients with CD4 <50 and was significantly less frequent in higher CD4 groups ($p = 0.012$). Similarly, diastolic dysfunction ($p = 0.021$), pericardial effusion ($p = 0.030$), and pulmonary hypertension ($p = 0.041$) were all more prevalent among those with the lowest CD4

counts. The prevalence of these abnormalities diminished in parallel with improving immune status. Only 13% of those with CD4 >350 had reduced LVEF, and diastolic dysfunction was present in just 4.3% of this group. This gradient underscores the strong inverse association between immune competence and structural/functional cardiac abnormalities in HIV-positive individuals.

4. Discussion

Cardiovascular complications in individuals with HIV/AIDS are gaining increased recognition, particularly in developing countries. However, these cardiac issues are often underdiagnosed, as symptoms such as fatigue, breathlessness, and reduced exercise tolerance are frequently attributed to other HIV-related conditions. Identifying cardiovascular abnormalities in HIV-positive individuals is therefore crucial. Common cardiac manifestations in this population include pericardial effusion, left ventricular (LV) systolic dysfunction, cardiomyopathies, and intracardiac masses[14].

Among these, heart muscle disease stands out as the most significant cardiac manifestation of HIV. As the life expectancy of HIV-positive patients continues to improve with effective antiretroviral therapy, the prevalence of myocardial involvement is expected to rise. The mechanisms behind this cardiac involvement are complex and multifactorial. They may include direct myocardial infection by the virus, opportunistic infections, autoimmune reactions triggered by viral antigens, cardiotoxic effects of antiretroviral or other medications, nutritional deficiencies, and the effects of chronic immune suppression[15].

In the present study, we examined the echocardiographic and electrocardiographic findings in 100 HIV-infected individuals and explored their correlation with CD4 counts. The mean age of participants was 43.3 ± 9.46 years, with most falling in the 40–49 age range. A marked male predominance (78%) was noted, and a large majority (81%) were receiving antiretroviral therapy (ART), indicating relatively good ART coverage. Similar to our study, Marwadi M et al[16]. among 100 cases observed a mean age of 32.2 years with 75% male preponderance in their study and Singh et al[17]. studied 100 patients, with a mean age of 39.9 years, and a male-to-female ratio of 1.7:1, whereas Ogunmodede et al[18]. analyzed 150 HIV-positive patients and 150 matched controls, with mean age 37.3 ± 8.9 years, and a relatively balanced sex distribution (57.3% females) in their research. In accordance to our study findings, the Zambian study by Kabwe et al[19]. assessed 243 asymptomatic HIV-positive adults, with a mean age of 42.4 years and a majority being female (58.5%) and similarly, Sharma et al[20]. studied 100 consecutive HIV patients with ages ranging from 15 to 80 years, with a mean age of 41.37 years and a male to female ratio of 3:1 (75% males and 25% females). However, in contrary to our findings, Okechukwu et al[21]. studied 126 HIV-positive children/adolescents aged 7–18 years with a similar gender distribution (52.4% males), and mean age of 14.1 ± 3.1 years in their study, which was lower than our study.

In our study, the average body mass index (BMI) was 23.5 ± 4.3 kg/m^2, suggesting a generally normal weight profile with a subset of underweight individuals. The mean duration of HIV infection was 10.3 years, reflecting a population with prolonged exposure to the virus and its treatments. At the same time, Ogunmodede et al[18]. observed that the BMI and weight were considerably lower in HIV-positive patients than controls (BMI: 21.3 vs. 25.1 kg/m^2, $P < 0.001$), highlighting the nutritional impact of chronic HIV infection. However, Okechukwu et al[21]. showed a high prevalence of undernutrition, with 57.9% underweight (BMI <18 kg/m^2) and a mean BMI of 17.6 ± 3.5 kg/m^2.

In our study, despite widespread ART use across all CD4 strata, with 81% of participants on treatment, there was no significant relationship between ART status and CD4 count category ($p = 0.388$). This suggests that while ART use is high, it may not always reflect immune reconstitution, particularly in individuals with persistently low CD4 counts despite therapy.

In the present study, CD4 counts ranged widely, with nearly half (46%) having CD4 counts >350 cells/mm^3. However, 38% had CD4 counts <200, indicating significant immunosuppression in a notable subset and the mean CD4 count was 336.8 ± 229.1 cells/mm^3. Similarly, the Marwadi M et al[16]. study had 67% of participants with CD4 counts under 200 cells/mm^3, including 9% with CD4 counts below 50 cells/mm^3, indicating a population with more advanced immunosuppression, while Singh et al[17]. found 41% of patients had CD4 counts between 201–500 cells/μL and 36% had counts between 51–200 cells/μL, with only 5% <50 cells/μL and the mean CD4 count in their study was 313.7 ± 237.6 cells/μL and in the Kabwe et al[19]. study, CD4 count distribution was fairly even, with 57.6% having CD4 ≤350 cells/mm^3. Also, Shrinivas et al[22]. reported that among the 50 HIV-positive patients studied, 32% had CD4+ T cell counts exceeding 200 cells/mm^3, while 12% had counts below 50 cells/mm^3. Similarly, the CD4 count distribution in Sharma et al[20]. study showed that 27.3% had CD4 counts <50 cells/mm^3, 34.6% had CD4 counts between 50-199 cells/mm^3, 25.4% had counts between 200-499 cells/mm^3, and 12.7% had counts >500 cells/mm^3.

In our study, ECG abnormalities were common, with sinus tachycardia being the most prevalent (30%), followed by low voltage complexes (11%), whereas in the Marwadi M et al[16]. study, the most common abnormality on ECG was sinus tachycardia, seen in 24% of patients, followed by left ventricular hypertrophy (LVH) was noted in 8%, and low voltage complexes were observed in 6% of patients. Although none of our ECG findings were statistically significantly associated with CD4 categories, trends indicated that lower CD4 counts corresponded to a higher prevalence of abnormalities such as sinus tachycardia, low voltage complexes, and conduction disturbances, where Sinus tachycardia, was most common in the CD4 <50 group (57.1%) and decreased across higher CD4 categories to only 13% in those with CD4 >350 ($p = 0.207$). Low voltage complexes, which may be indicative of pericardial effusion or myocardial pathology, were present in 57.1% of those with CD4 <50 and absent in the CD4 >350 group ($p = 0.296$) in our study.

In the present study, while axis deviations and conduction abnormalities were rare overall (1% RAD, 4% LAD), they appeared disproportionately in the CD4 <50 group. Left axis deviation was present in 42.9% of those with the lowest CD4 counts but not in higher categories ($p=0.622$) and right axis deviation present among 3.2% in the 50-199 CD4 category only ($p=0.756$). Conduction block changes ($p=0.075$) and ST-segment abnormalities ($p=0.076$) were also primarily seen in the lowest CD4 group and were not significant. Although the p-values for these comparisons were just above the threshold for significance, the clinical implications are important.

Similar to our study, Singh et al[17]. reported ECG abnormalities in 49% of patients, with a clear correlation to low CD4 count: 80% of patients with CD4 <50/μL had abnormal ECGs vs. only 26.4% in those with CD4 >500/μL. Sinus tachycardia was also the most common abnormality (27%), followed by low voltage QRS (7%), ST-T changes (8%), and LVH (10%). Each of these showed statistically significant associations with lower CD4 counts ($p<0.05$) in their study respectively. At the same time, in the Ogunmodede et al[18]. study, ECG abnormalities were also prevalent among the HIV-positive participants, with 55.3% showing at least one abnormality, compared to just 2.7% in controls ($P < 0.001$). The most common abnormalities included prolonged corrected QT interval (QTc) in 34.7% ($P < 0.001$), left ventricular hypertrophy (LVH) in 17.3%, and left atrial enlargement (LAE) in 20%. Right atrial enlargement (RAE), premature ventricular contractions (PVCs), and right ventricular hypertrophy (RVH) were noted in 7.3%, 8%, and 8.7% respectively.

Likely, Shrinivas et al[22]. reported that 28% of patients with pericardial effusion exhibited abnormalities in CD4 counts. Among these, mild effusion was observed in 22% of cases, moderate in 4%, and large effusion in 2%. Their study also indicated a correlation between the severity of pericardial effusion and declining CD4 cell counts, with more severe effusions occurring in patients with lower CD4 levels. At the same time, Sharma et al[20]. found that 54.3% of their cohort exhibited echocardiographic abnormalities and the most common abnormalities included reduced ejection fraction (14.3%), fractional shortening (46.3%), pericardial effusions (16.6%), and diastolic dysfunction (9.25%) and found a clear correlation between CD4 counts and cardiac abnormalities with mean CD4 counts of 128 ± 108, where most echocardiographic findings were seen in their patients with CD4 counts less than 50 cells/mm^3.

5. Conclusion

Our study highlights a significant correlation between immune status, as measured by CD4 count, and various echocardiographic and electrocardiographic abnormalities in people living with HIV. Specifically, lower CD4 counts were significantly associated with reduced ejection fraction, diastolic dysfunction, and pericardial effusion, with p-values of 0.012, 0.021, and 0.030 respectively. There was also a statistically significant moderate positive correlation between CD4 count and ejection fraction ($r = 0.395$, $p = 0.001$) (Figure 2), emphasizing the role of immune competence in preserving cardiac function. These results suggest that advanced immunosuppression contributes to both systolic and diastolic dysfunction, as well as structural and conduction abnormalities detectable on 2D ECHO and ECG.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

Approved by the Institutional Ethical Committee of Al-Ameen Medical College and Hospital (Ref No: IEC/AMC/2023/102).

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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