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Cardiac Manifestations in People Living with HIV: A Cross-Sectional Echocardiographic and ECG-Based Study from a Sudanese Tropical Teaching Hospital

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ABSTRACT

Background: People living with HIV (PLHIV) are more likely to have cardiovascular problems since they live longer due to antiretroviral therapy (ART). The goal of this study was to look at ECG and echocardiographic abnormalities in HIV-positive patients in Omdurman Tropical Disease Teaching Hospital.

Materials and Methods: A cross-sectional study involving 93 PLHIV was conducted between November 2020 and April 2021. Each patient underwent an ECG and an echocardiogram, and their clinical data, including WHO stage at diagnosis, ART regimen, and disease duration, were recorded. This comprehensive data collection enabled us to thoroughly investigate the relationship between QT prolongation or diastolic dysfunction and various clinical factors.

Results: The predominant gender was female, including 46 out of 93 individuals. The average age was 38.9 ± 9.1 years. Among the total patients, 21.5% demonstrated diastolic dysfunction, 10.8% presented with left ventricular hypertrophy (LVH), 8.6% revealed tricuspid regurgitation, and 4.3% experienced moderate pulmonary artery hypertension (SPAP >35 mmHg). QT prolongation occurred in 26.9% of instances. ECG abnormalities were observed in 60.2% of individuals. Among these, longer QT intervals (26.9%) and ST-T alterations (12.9%) were the most prevalent observations. Gender exhibited a statistically significant correlation with QT prolongation (P = 0.006), while age showed a significant association with diastolic dysfunction (P = 0.036).

Conclusion: Diastolic dysfunction and QT prolongation are common cardiac issues among HIV-infected patients. Routine heart check-ups should be part of HIV care, especially in older populations. Gender and age play key roles in specific heart problems in PLHIV. Additional studies are required to elucidate progression patterns and provide targeted therapies.

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Introduction

Cardiovascular problems in HIV-positive people are a facet of worldwide HIV care that doesn't get enough attention or research, especially in low-resource tropical places like Sudan. Antiretroviral therapy (ART) has increased the life expectancy of people with HIV, but chronic comorbidities, such as heart problems, have become major causes of illness and death [1].

HIV-related heart problems, from mild subclinical diastolic dysfunction to severe heart failure, conduction problems, and arrhythmias, are a significant concern. These problems are caused by a combination of viral replication, immune system issues, systemic inflammation, and potential toxicity from ART [2,3]. However, despite the established global trends, it's important to note that cardiovascular screening is not a regular aspect of HIV care in many parts of sub-Saharan Africa, highlighting a crucial area for improvement [4].

In Sudan, where the healthcare system is already stretched thin and HIV represents a distinct clinical burden, there isn't much data on cardiac symptoms that is specific to the area. In this case, the relationship between ART duration, disease stage, and demographic factors, including gender and age, as well as cardiovascular measures, remains largely unknown. Your role in addressing these knowledge gaps is crucial. It is important to note that non-invasive tests like electrocardiography (ECG) and echocardiography are available and could improve the way we diagnose early heart abnormalities in HIV patients before damage becomes [5].

This thorough study will fill in an enormous gap by looking into how often and what kinds of ECG and echocardiographic problems HIV-positive patients have at a tropical teaching hospital in Sudan. It also examines the association between cardiac outcomes and clinical parameters, including ART exposure, disease duration, age, and sex. The study's thorough approach ensures that evidence-based screening methods are developed that are effective and reliable in real-world healthcare settings.

Materials and Methods

Study Design and Setting

This study employed a cross-sectional descriptive analysis conducted at the Omdurman Tropical Teaching Hospital in Sudan. The hospital serves as a tertiary referral center, offering a specialized HIV clinic that provides antiretroviral therapy (ART) and regular follow-up care. The study duration extended over six months (November 2020 – April 2021), focusing on HIV-positive people with diverse antiretroviral therapy exposure histories.

Study Population

A total of 93 HIV-positive adults were enrolled. They were chosen through successive sampling from both outpatient and inpatient facilities. The following were the criteria for inclusion: ELISA and Western blot tests showed that the person was HIV-positive. Age: 18 or older. The participants' consent was obtained with full knowledge and care, ensuring the ethical conduct of the study. Some of the reasons for exclusion were: Congenital cardiac disease is known. A history of high blood pressure or rheumatic heart disease. Pregnancy (due to altered hemodynamics).

Data Collection

Using a structured questionnaire, each participant had a complete clinical evaluation, which included their age, gender, height, weight, and BMI, how long they had been infected with HIV, how long they had been on ART, and how the WHO stages HIV.

WHO HIV Clinical Classification

The World Health Organization's Clinical Staging System for HIV/AIDS, which can be used in places with few resources, was used to divide patients into stages [6]:

WHO Stage	Description
Stage 1	Asymptomatic or persistent generalized lymphadenopathy
Stage 2	Mild symptoms such as weight loss
Stage 3	Advanced symptoms include severe weight loss (>10%), chronic diarrhea, prolonged fever, and oral candidiasis.
Stage 4	AIDS-defining illnesses: Kaposi's sarcoma, PCP, extrapulmonary TB, HIV wasting syndrome

This categorization lets you stage without relying on CD4 count or viral load, and it was used to look into links between HIV severity and heart problems.

Electrocardiographic Evaluation

Standard 12-lead electrocardiograms were conducted and analyzed by proficient physicians. The evaluated parameters included heart rate, PR interval, QRS shape and duration, QT and QTc intervals (Bazett's algorithm), rhythm, and conduction blocks. Abnormal QTc was determined as ≥440 ms in males and ≥460 ms in females, by established criteria [7].

Echocardiographic Assessment

We, certified sonographers, conducted a thorough two-dimensional transthoracic echocardiography using portable devices. They assessed the following parameters: chamber dimensions and wall thickness, left ventricular ejection fraction (LVEF), diastolic function as indicated by the E/A ratio, valve morphology and regurgitation, and estimation of pulmonary artery pressure using the TR jet. This assessment led to the detection of diastolic dysfunction due to an abnormal E/A ratio (12 mm).

Data Analysis

All collected data were input into IBM SPSS Statistics version 26 for analysis. Continuous variables were assessed for normality by the Shapiro-Wilk test, and those that were not normally distributed were analyzed using non-parametric alternatives. The baseline characteristics of the subjects, including age, gender, ART exposure, and WHO clinical stage, were summarized using Means and standard deviations for continuous variables that follow a normal distribution. Frequencies and proportions for categorical variables. Statistical methods were employed to discover significant connections between cardiac anomalies and clinical factors. Chi-square test (χ^2) for categorical comparisons (e.g., ECG abnormalities versus gender, QTc prolongation versus ART status). Independent Mann–Whitney U test for mean comparisons. Statistical significance was established at $p < 0.05$.

Ethical Consideration

Approval was secured from the institutional ethics committee of the Sudan Medical Specialization Board and the Omdurman Tropical Disease Teaching Hospital. All participants granted informed written consent. Data confidentiality and privacy were rigorously upheld throughout the investigation.

Results

Ninety-three patients in this study had HIV, with a sex distribution of 49 (52.7%) women and 44 (47.3%) men. The average age was 38.9 ± 9.1 years. The body mass index (BMI) of most of the patients (52.7%) was normal (18.5–24.9 kg/m²). However, 25.8% were overweight, 12.9% were obese, and 8.6% were underweight. The disease lasted more than five years in 62.4% of the patients, and 37.6% had been diagnosed in the last five years. When it comes to illness staging, 40.9% of patients were diagnosed at WHO stage III or IV, and the remaining 59.1% were detected at earlier stages.

The majority of patients, a significant 91.4%, received the Lamivudine (3TC), disoproxil fumarate (TDF), Efavirenz (EFV) regimen, which is the first-line ART regimen. The remaining 7.5% were administered the 3TC, Zidovudine (AZT), EFV regimen, classified as second-line treatment.

It's noteworthy that 22.6% of patients exhibit cardiac symptoms, with palpitations being the most common (17.2%), followed by chest discomfort (9.7%) and dyspnea (5.4%). Blood pressure assessments indicated that 18.3% of individuals have hypertension, with two patients recording values over 160/100.

ECG Findings

ECG abnormalities were identified in 60.2% of patients, with QT interval lengthening as the predominant result, noted in 26.9% of patients. The mean QTc is 440 ms, with a statistically significant predominance in female patients (P = 0.049), a vital factor that should be considered in patient care. Prolonged QTc intervals may signify an elevated risk of arrhythmia and may indicate myocardial effects associated with ART or inflammatory processes.

The data on conduction and rhythm disturbances are significant: First-degree AV block: 2.2%, Second-degree AV block: 2.2%, PR interval deviations: 6.4%, Abnormal QRS morphology: 6.5% (Table 1). This needs careful monitoring and intervention. Axis deviations and bundle branch blocks indicate the development of structural conduction disease. Tachycardia and bradycardia may indicate autonomic dysfunction or a reaction to ART toxicity. The occurrence of ventricular ectopic beats, though rare, is a significant indicator of subclinical arrhythmic risk. These data highlight the complex and varied electrophysiological effects of HIV and its treatments.

Echocardiography
The prevalence of echocardiographic abnormalities was significant, identified in 51.6% of the sample group, with several structural changes noted: Diastolic dysfunction was recognized as the predominant echocardiographic abnormality, impacting 21.5% of subjects (Figure 1). This exhibited a strong correlation with advancing age (P = 0.036), suggesting that age-related myocardial stiffness may be aggravated by chronic inflammation in HIV. Diastolic dysfunction was substantially correlated with illness duration (P = 0.043). This connection highlights the progressive cardiac burden that diastolic dysfunction might exert over time in HIV patients.

Interestingly, left ventricular hypertrophy (LVH) was observed in 10.5% of patients, indicating it could be a sign of chronic cardiac stress caused by inflammation, ART-related dyslipidemia, or other concomitant conditions. Moreover, Tricuspid regurgitation was identified in 8.6% of cases, but aortic regurgitation was observed in only 2.2% of cases. Pulmonary pressures were mildly to moderately high in 8.6% (Table 2), indicating early pulmonary hypertension, maybe attributable to immunological dysregulation or opportunistic infections. Additionally, ventricular ectopics were observed in 10.8% of patients with arrhythmic issues. One patient displayed supraventricular ectopics, whilst another presented with atrial fibrillation. All patients had preserved left ventricular ejection fraction (LVEF) (>50%), with a mean value of 66.03 ± 6.73%. There were no statistically significant correlations between changes in QTc or echocardiography and BMI, ART duration, or WHO staging; however, patterns may suggest that some effects aren't immediately apparent.

Table 1: Detailed ECG Abnormalities

ECG Abnormality	Frequency (n/%)
ST-segment abnormality	25 (26.9%)
Tachycardia	18 (18.1%)
Left axis deviation	13 (13.1%)
Right axis deviation	12 (12.1%)
Left bundle branch block (LBBB)	6 (6.5%)
Abnormal QRS morphology	6 (6.5%)
PR interval variations	6 (6.4%)
T wave abnormalities	4 (4.3%)
QTc prolongation	25 (26.9%)
Ventricular ectopic beats	4 (4.3%)
LVH by ECG criteria	4 (4.3%)
Bradycardia	4 (4.1%)
Short PR interval	3 (3.2%)
Right bundle branch block (RBBB)	2 (2.2%)
First-degree AV block	2 (2.2%)
Second-degree AV block	2 (2.2%)
P wave abnormalities	1 (1.0%)
Prolonged PR interval	0 (0.0%)

Table 2: Echo Abnormalities among HIV Patients

Variable	No. / %
Aortic regurgitation	2 (2.2%)
Tricuspid regurgitation	8 (8.6%)
SPAP Mild (> 25-35) Moderate (>35)	 4 (4.3%) 4 (4.3%)
Diastolic dysfunction	20 (21.3%)
Left ventricular hypertrophy	10 (10.5%)

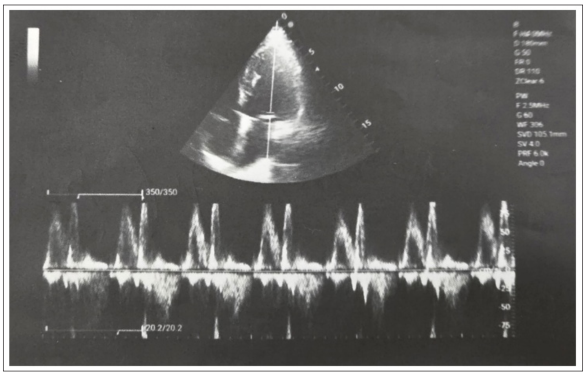

Figure 1: Echocardiographic of Left Ventricular (diastolic dysfunction) in a Patient with HIV-Associated Cardiac Manifestations

Discussion
This study illustrates a substantial prevalence of cardiac abnormalities in HIV-positive patients at a Sudanese tropical teaching hospital, emphasizing global concerns that cardiovascular disease (CVD) is an increasingly critical comorbidity in the context of extended antiretroviral therapy (ART) [1,3]. The significant occurrence of electrocardiographic (60.2%) and echocardiographic (31.2%) anomalies indicates that cardiac involvement in HIV may be inadequately acknowledged, especially in resource-constrained environments [8,9]. These findings advocate for the incorporation of cardiovascular screening into standard HIV therapy, particularly in low-income environments where asymptomatic cardiac impairment may frequently occur and is generally neglected.

The observation that 26.9% of patients displayed prolonged QTc intervals, with a statistically significant predominance among female patients, aligns with the current literature, which connects QTc alterations to ART-related effects, particularly those associated with protease inhibitors and non-nucleoside reverse transcriptase inhibitors (NNRTIs) [10]. This highlights the importance of considering gender differences in HIV treatment. QTc prolongation is clinically significant due to its correlation with ventricular arrhythmias and sudden cardiac death. The gender disparity may be ascribed to sex-specific hormonal effects on cardiac repolarization and pharmacokinetic variability in antiretroviral therapy metabolism [11].

Reduced occurrences of AV block and atypical QRS shape indicate a diminished prevalence of significant conduction anomalies, aligning with previous studies in African populations. Nevertheless, these observations may increase with disease progression or in untreated patients [12, 13].

Echocardiographic anomalies, primarily diastolic dysfunction (21.5%), indicate subclinical myocardial damage. This damage is potentially caused by chronic inflammation, microvascular malfunction, and direct viral cardiotoxic effects [14,15]. The statistically substantial correlation with disease duration suggests a cumulative cardiac load, consistent with findings from South African and Kenyan studies that demonstrate HIV-associated diastolic alterations even in asymptomatic patients [16]. These potential causes highlight the need for further research in this area.

Curiously, left ventricular hypertrophy (10.8%) may indicate persistent hemodynamic strain, potentially intensified by HIV-related metabolic anomalies, such as dyslipidemia and hypertension common in ART-treated cohorts [17,18]. These comorbidities induce pressure overload and myocardial remodeling. Tricuspid regurgitation (4.3%), while less common, may indicate increased pulmonary artery pressures or early right-sided heart strain. This condition is potentially a result of careful monitoring of HIV patients for ART-induced vascular alterations, chronic immune activation, or opportunistic pulmonary infections [15, 19].

Our findings necessitate the augmentation of cardiac screening methods in HIV care, particularly for women and patients with chronic disease. Electrocardiography and echocardiography are non-invasive, cost-effective modalities that can detect early heart impairment, facilitating prompt intervention before clinical decline. Considering Sudan's limited healthcare infrastructure, educating primary care practitioners in fundamental cardiac assessment and incorporating cardiovascular evaluations into ART follow-up protocols may alleviate long-term consequences. This study provides geographically significant insights by focusing on HIV-positive patients in Sudan, a demographic where cardiac symptoms are under-researched. By integrating ECG and echocardiographic assessments, it provides a comprehensive perspective on both electrical and structural heart changes, practically and efficiently. Significantly, stratified results such as QTc prolongation in females and diastolic dysfunction associated with disease duration offer actionable targets for therapeutic screening. The use of accessible, non-invasive diagnostics enhances its viability in resource-limited settings, emphasizing the practicality of scaling its incorporation into HIV care.

The limitations of this study include its single-center design, which restricts generalizability to broader Sudanese healthcare contexts, and its cross-sectional character, which limits the causal interpretation of cardiac abnormalities. The quantitative echocardiographic measurements were not thoroughly evaluated, which may have led to an underestimation of illness severity. Also, we having no treatment free arm to evaluate effect of the disease itself and its treatments. Moreover, selection bias may have affected the results due to tertiary-care enrollment, and confounding comorbidities such as hypertension, diabetes, and ART regimens were not thoroughly stratified. The lack of longitudinal follow-up inhibits comprehension of the progression or reversibility of cardiac alterations over time.

Conclusion

This study demonstrates a significant prevalence of cardiac abnormalities in HIV-positive patients in a Sudanese tropical teaching hospital, with electrocardiographic alterations observed in more than half of the participants and echocardiographic dysfunction identified in approximately one-third. Extended QTc intervals, particularly in female patients, and diastolic dysfunction associated with disease duration highlight the covert cardiovascular impact of persistent HIV infection and antiretroviral treatment. These findings necessitate the proactive incorporation of cardiac screening into standard HIV therapy, utilizing accessible modalities such as ECG and echocardiography to identify subclinical alterations before symptomatic advancement. Importantly, this strategy, demonstrated to be feasible in a resource-constrained environment, shows potential for a significant public health impact. Future multicenter, longitudinal studies are necessary to enhance comprehension of the temporal dynamics, ART-specific effects, and outcomes linked to HIV-related cardiac involvement, ultimately guiding targeted interventions to improve long-term survival and quality of life in HIV populations.

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