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A Case-Control Study on Cardiac Structure and Function via Magnetic Resonance Imaging in People Living with HIV in the Dan'ao Region

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Abstract

Objective: To investigate the characteristics of cardiac structural and functional changes in HIV-infected patients (including asymptomatic and AIDS stages) in the Dan'ao region. We analyzed alterations in myocardial mass, atrial and ventricular dimensions, and ejection fraction, aiming to reduce patient mortality through the early detection of subclinical cardiac lesions. **Methods:** Study Subjects: We recruited HIV-infected patients visiting the "Love Clinic" between May 2024 and May 2025. The cohort included 30 patients with AIDS and 31 asymptomatic individuals. Additionally, 50 healthy volunteers were selected to serve as a control group. Grouping Criteria: Diagnosis and staging were performed strictly in accordance with the Chinese Guidelines for the Diagnosis and Treatment of HIV/AIDS (2024 Edition). Examination & Analysis: All participants underwent Cardiac Magnetic Resonance (CMR) imaging. Post-processing analysis was conducted using the United Imaging Intelligence (uAI) software to measure myocardial mass, atrial and ventricular dimensions, ventricular volumes, and ejection fraction. Statistical analysis was performed using SPSS 27. 0 software. **Results:** One-way ANOVA revealed a statistically significant difference among the three groups in Left Ventricular Ejection Fraction (LVEF) ($F = 8.445$, $P < 0.01$), right ventricular end-systolic and end-diastolic volumes ($F = 3.242$, $P = 0.04$), Left Ventricular Myocardial Mass (LVMM) ($F = 3.698$, $P = 0.03$) and Right Ventricular Ejection Fraction (RVEF) ($F = 4.073$, $P = 0.02$). Based on the one-way ANOVA results, pairwise comparisons were conducted between the AIDS group and the healthy control group, the AIDS group and the asymptomatic HIV group, and the asymptomatic HIV group and the healthy control group. AIDS group vs. Healthy control group: The results showed statistically significant differences in LVEF ($t = -3.831$, $P < 0.001$), RVESV ($t = 2.348$, $P = 0.02$), right atrial diameter ($t = 3.533$, $P < 0.001$), LVM ($t = 2.851$, $P < 0.01$), and RVEF ($t = -2.883$, $P < 0.01$). AIDS

group vs. Asymptomatic HIV group: Statistically significant differences were observed in LVEF ($t = -3.254$, $P < 0.01$). However, no significant differences were found in right atrial diameter ($t = 0.714$, $P = 0.49$), LVM ($t = 1.403$, $P = 0.17$), or RVEF ($t = 0.757$, $P = 0.45$). Asymptomatic HIV group vs. Healthy control group: No statistically significant differences were found in LVEF ($t = -0.542$, $P = 0.59$), RVESV ($t = -1.049$, $P = 0.30$), right atrial diameter ($t = 1.429$, $P = 0.16$), LVM ($t = 1.122$, $P = 0.25$), or RVEF ($t = -1.769$, $P = 0.08$). **Conclusion:** Left and right ventricular ejection fractions were lower in HIV-infected individuals, particularly those with AIDS, compared to the healthy control group. Conversely, right ventricular end-diastolic volume, right atrial anterior-posterior diameter, and cardiac mass were elevated. These findings suggest that HIV-infected individuals may suffer from right ventricular dysfunction, with more severe impairment observed in patients with AIDS.

Keywords

HIV Infection, AIDS, Cardiac Magnetic Resonance

1. Introduction

The cardiovascular system is one of the most frequently affected systems in patients with Human Immunodeficiency Virus (HIV), and AIDS remains a severe public health challenge. According to the World Health Organization (2025), by the end of 2024, there were 40.8 million people living with HIV/AIDS globally, with 1.3 million new infections and 630,000 AIDS-related deaths recorded throughout the year [1]. Patients with HIV-associated cardiovascular lesions are often asymptomatic in the early stages. Cardiac MRI allows for the timely detection of various related cardiovascular diseases and facilitates early intervention. This approach can effectively reduce mortality among AIDS patients, thereby yielding significant public health benefits. Studies have shown that HIV-infected adults without traditional cardiovascular risk factors typically maintain normal left ventricular systolic function. However, reduced left atrial reservoir function has been observed, suggesting the presence of early diastolic dysfunction [2]. Furthermore, research utilizing risk scores for predicting heart failure and cardiovascular events in relation to Cardiac Magnetic Resonance (CMR) imaging has indicated that myocardial structural alterations in asymptomatic HIV-infected individuals are associated with inflammatory markers [3]. Currently, there is a paucity of research and data regarding cardiac MR in HIV patients within Guangdong province. This case-control study utilized cardiac MRI to assess myocardial mass and atrioventricular dimensions in patients with HIV.

2. Materials and Methods

2.1. Study Subjects and Methods

We recruited confirmed, treatment-naïve HIV-infected patients visiting the "Love Clinic" between May 2024 and May 2025. Inclusion Criteria: 1) Confirmed diag-

nosis of HIV infection; 2) Age ≥ 18 years. Exclusion Criteria: 1) Contraindications to MRI, such as metallic implants or claustrophobia; 2) Acute kidney injury, chronic or severe renal disease, or a glomerular filtration rate (GFR) < 30 ml/(min·1.73 m^2); 3) High fever, severe respiratory disease preventing breath-holding, or critical illness; 4) Poor image quality precluding post-processing; 5) Pregnancy; 6) Family history of cardiovascular disease; 7) History of congenital heart disease; 8) History of diabetes mellitus.

Concurrently, 50 healthy individuals were selected from the physical examination center as a control group, matched by gender and age using stratified sampling.

2.2. Patient Grouping

A total of 61 patients were finally included: 30 patients with AIDS (23 males, 7 females) and 31 asymptomatic HIV-infected individuals (24 males, 7 females). The Asymptomatic HIV Group consisted of patients in the asymptomatic stage. These individuals lack clinical symptoms but test positive for HIV RNA and antibodies to core and envelope proteins in their blood, remaining infectious [4]. The AIDS Group consisted of patients in the terminal stage of HIV infection. These patients may present with Acquired Immunodeficiency Syndrome, clinically manifesting as various opportunistic infections (e.g., Toxoplasma, Cryptosporidium), viral infections (e.g., Cytomegalovirus, Herpes Simplex Virus), fungal infections, and various malignancies (e.g., Kaposi's sarcoma, Lymphoma). All cases were diagnosed according to the Chinese Guidelines for the Diagnosis and Treatment of HIV/AIDS (2024 Edition) [5].

2.3. Measurement Tools

Cardiac magnetic resonance (CMR) data were analyzed using the United Imaging Intelligence (uAI) software. The following parameters were acquired: left ventricular myocardial mass (LVMM), left and right atrial anterior-posterior diameters (LAD/RAD), left and right ventricular end-diastolic diameters (LVEDD/RVEDD), left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), left ventricular ejection fraction (LVEF), right ventricular end-diastolic volume (RVEDV), and right ventricular end-systolic volume (RVESV).

2.4. Statistical Analysis

Statistical analysis was performed using SPSS 27 software. Continuous variables were analyzed using Analysis of Variance (ANOVA), and categorical data were analyzed using the Chi-square test. A P-value < 0. 05 was considered statistically significant.

3. Results

3.1. General Characteristics

The general characteristics of the groups are presented in **Table 1**. The results

indicated that there were no statistically significant differences among the three groups in terms of age, gender, systolic blood pressure, diastolic blood pressure, and heart rate, Smoking, Body mass index, serum creatinine, triglycerides, total cholesterol, fasting plasma glucose, and HIV baseline viral load.

Table 1. Comparison of general characteristics and cardiac MR results among the three groups.

	AIDS Group (30)	HIV Asymptomatic Group (31)	Healthy Control Group (50)	$t/Z/\chi^2$	*P*-Value
Age	49.77 ± 12.40	48.87 ± 11.58	51.18 ± 7.10	0.531	0.59
Gender (Male/Female)	23/7	24/7	38/12	0.022	0.99
Systolic Blood Pressure	103.61 ± 7.80	103.97 ± 7.76	104.47 ± 8.03	0.119	0.89
Diastolic Blood Pressure	69.00 ± 4.75	68.80 ± 4.90	68.75 ± 4.77	0.028	0.97
Smoking, n (%)	6 (16.7%)	7 (22.4%)	12 (24%)	0.172	0.92
Body Mass Index	21.27 ± 1.28	21.11 ± 1.28	21.11 ± 1.18	0.191	0.83
Serum Creatinine (μmol/L) [25%, 75%]	80.35 [78.25, 82.58]	80.4 [77.9, 82.7]	80.30 [77.98, 82.05]	0.031	0.99
Triglycerides (mmol/L) [25%, 75%]	1.07 [0.93, 1.20]	1.05 [0.89, 1.19]	1.05 [0.90, 1.18]	0.237	0.89
Total Cholesterol (mmol/L) [25%, 75%]	4.03 [3.83, 4.22]	4.00 [3.80, 4.22]	4.01 [3.78, 4.21]	0.237	0.89
Fasting Plasma Glucose (mmol/L) [25%, 75%]	5.0 [4.58, 5.50]	4.80 [4.30, 5.30]	4.90 [4.38, 5.43]	0.519	0.77
Heart Rate	75.90 ± 8.37	77.07 ± 9.82	77.67 ± 10.38	0.318	0.73
LVMM (gm_2)	58.34 ± 7.84	55.00 ± 10.53	52.46 ± 9.56	3.698	0.03
LAD/LA-AP (mm)	32.58 ± 4.88	32.40 ± 4.17	32.10 ± 4.82	0.11	0.90
RAD/RA-AP (mm)	43.83 ± 3.25	42.74 ± 7.74	40.92 ± 3.76	3.346	0.04
LVEDD (mm)	49.29 ± 2.61	50.30 ± 2.77	48.82 ± 3.39	2.252	0.11
RVEDD (mm)	26.77 ± 2.33	26.90 ± 2.11	27.39 ± 2.53	0.786	0.46
LVEDV (mlm_2)	117.36 ± 24.36	116.69 ± 23.68	121.40 ± 23.09	0.482	0.62
LVESV (mlm_2)	44.83 ± 13.02	44.15 ± 13.05	42.09 ± 13.36	0.481	0.62
LVEF (%)	63.33 ± 5.30	67.48 ± 4.66	68.13 ± 5.52	8.445	<0.01
RVEDV (mlm_2)	92.72 ± 22.84	84.56 ± 21.88	81.25 ± 18.95	0.472	0.63
RVESV (mlm_2)	89.90 ± 16.70	86.69 ± 13.33	81.29 ± 15.49	3.242	0.04
RVEF (%)	55.97 ± 4.91	57.14 ± 6.94	59.71 ± 6.01	4.073	0.02
$CD4^+$T Lymphocytes (count/ul) [25%, 75%]	177 [102.25, 426.5]	459 [362, 562]	-	8.689	<0.01
HIV Baseline Viral Load (log_{10})	5.20 ± 0.47	5.32 ± 0.37	-	−1.123	0.266

In terms of Left Ventricular Ejection Fraction (LVEF), the AIDS group showed significantly lower values compared to both the Healthy Control group and the Asymptomatic HIV group ($F = 8.445$, $P < 0.01$). Both the AIDS and asymptomatic HIV groups exhibited significantly higher right ventricular end-systolic and end-diastolic volumes compared to the Healthy Control group ($F = 3.242$, $P = 0.04$). For Left Ventricular Myocardial Mass (LVMM), the values followed a descending order: AIDS group > Asymptomatic HIV group > Healthy Control group ($F = 3.698$, $P = 0.030$). Conversely, Right Ventricular Ejection Fraction (RVEF) showed an inverse trend, with the Healthy Control group > Asymptomatic HIV group > AIDS group (F = 4.073, $P = 0.02$). The Right Atrial Anterior-Posterior Diameter also followed a descending trend (AIDS > Asymptomatic HIV > Healthy Control) (F = 3.346, $P = 0.04$), with the AIDS group presenting the largest right atrial diameter (Figures 1-5).

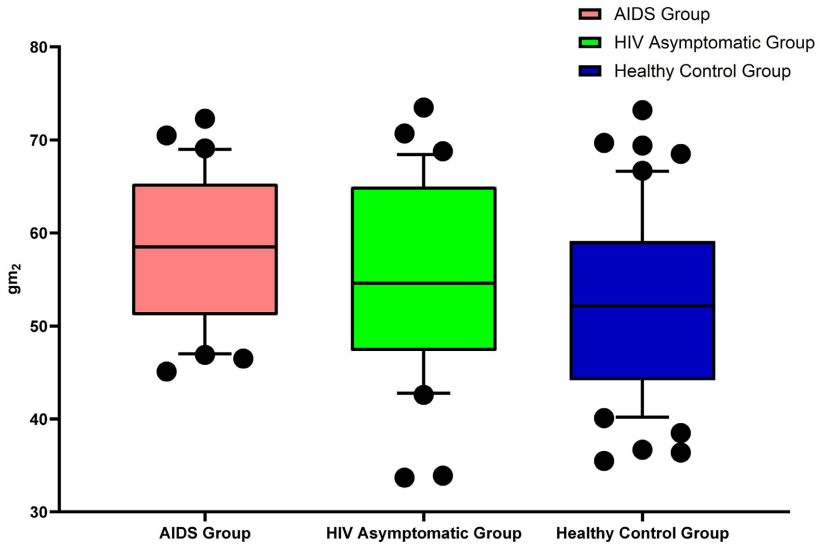

Figure 1. Boxplot of the three groups' comparison in LVMM.

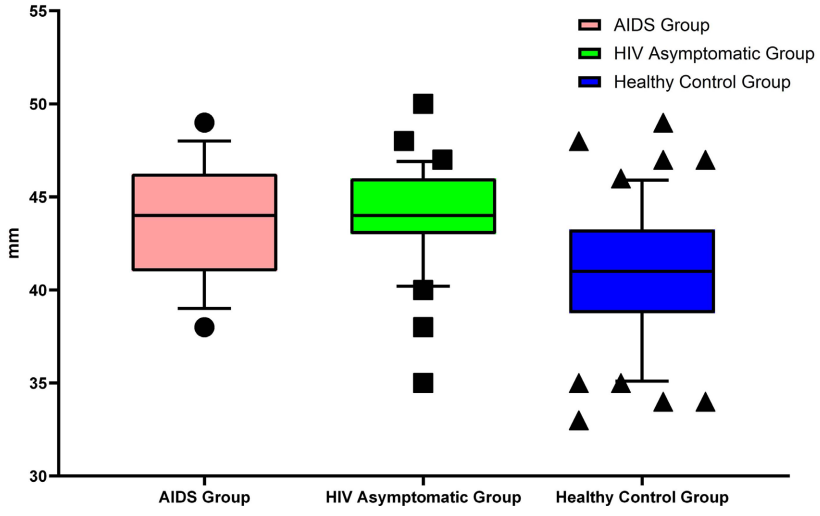

Figure 2. Boxplot of the three groups' comparison in RAD/RA-AP.

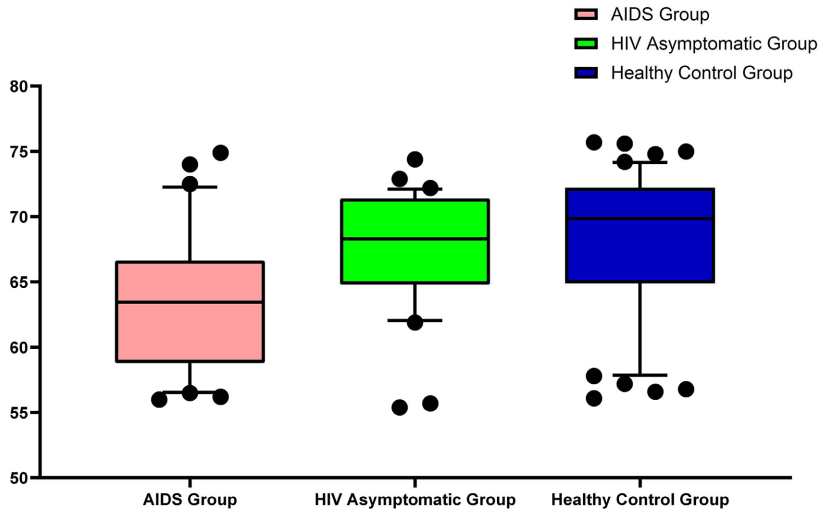

Figure 3. Boxplot of the three groups' comparison in LVEF.

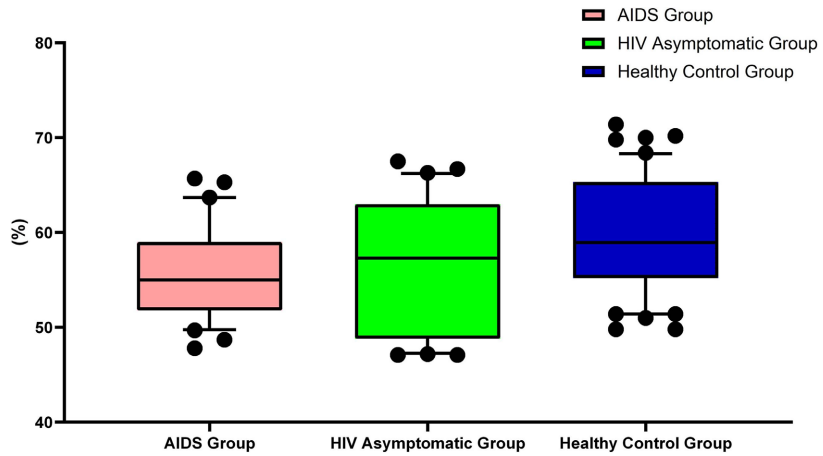

Figure 4. Boxplot of the three groups' comparison in RVEF.

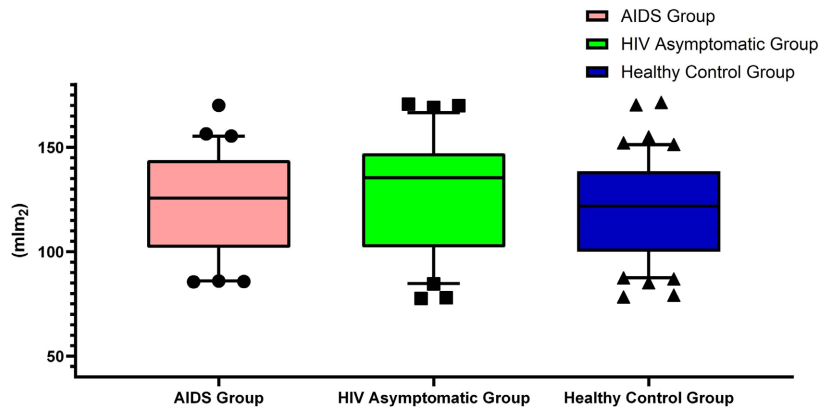

Figure 5. Boxplot of the three groups' comparison in RVESV.

However, no statistically significant differences were observed among the three groups in terms of Left Ventricular End-Diastolic Diameter ($F = 2.252$, $P = 0.11$), Right Ventricular End-Diastolic Diameter ($F = 0.786$, $P = 0.46$), Left Ventricular

End-Diastolic Volume ($F = 0.482$, $P = 0.62$), Left Ventricular End-Systolic Volume ($F = 0.481$, $P = 0.62$), or Regarding Right Ventricular End-Diastolic Volume ($P = 0.472$, $P = 0.63$).

3.2. Comparison among Groups

Based on the one-way ANOVA results, pairwise comparisons were conducted between the AIDS group and the Healthy Control group, the AIDS group and the asymptomatic HIV group, and the asymptomatic HIV group and the Healthy Control group.

AIDS group vs. Healthy Control group: The results showed statistically significant differences in LVEF ($t = -3.831$, $P < 0.001$), RVESV ($t = 2.348$, $P = 0.02$), right atrial diameter ($t = 3.533$, $P < 0.001$), LVM ($t = 2.851$, $P < 0.01$), and RVEF ($t = -2.883$, $P < 0.01$) (Figure 6).

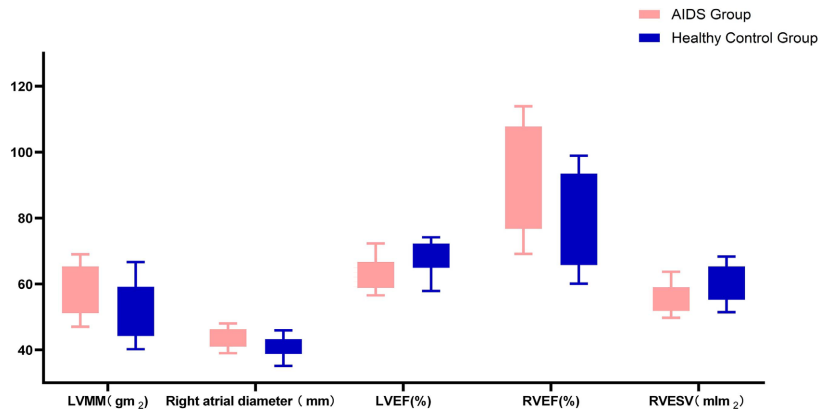

Figure 6. Comparison between the AIDS group and the Healthy Control group.

AIDS group vs. Asymptomatic HIV group: Statistically significant differences were observed in LVEF ($t = -3.254$, $P < 0.01$). However, no significant differences were found in right atrial diameter ($t = 0.714$, $P = 0.49$), LVM ($t = 1.403$, $P = 0.17$), or RVEF ($t = 0.757$, $P = 0.45$) (Figure 7).

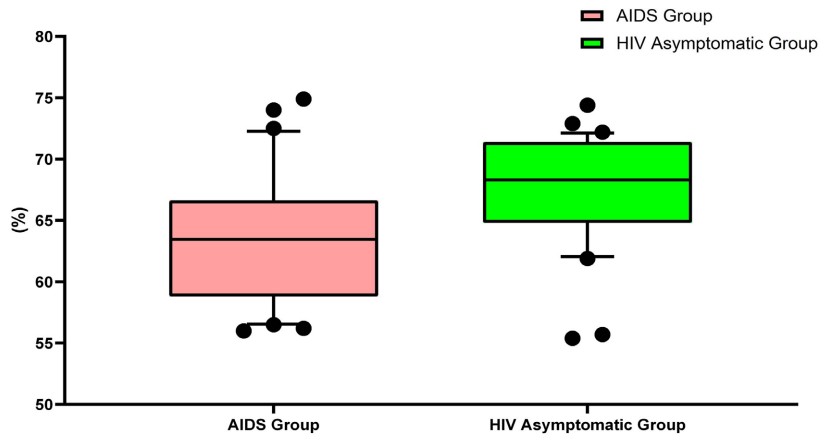

Figure 7. Comparison between the AIDS group and the asymptomatic HIV group.

Asymptomatic HIV group vs. Healthy Control group: No statistically significant differences were found in LVEF ($t = -0.542$, $P = 0.59$), RVESV ($t = -1.049$, $P = 0.30$), right atrial diameter ($t = 1.429$, $P = 0.16$), LVM ($t = 1.122$, $P = 0.25$), or RVEF ($t = -1.769$, $P = 0.08$).

4. Discussion

Currently, cardiac magnetic resonance (CMR) imaging is increasingly being utilized in research concerning HIV-associated cardiac diseases. Both domestically and internationally, CMR has established itself as a pivotal diagnostic tool for detecting cardiac pathology, particularly cardiomyopathies, offering distinct advantages over echocardiography.

Characterized by multi-parametric, multi-planar, and multi-sequence imaging capabilities, CMR allows for a "one-stop" evaluation of cardiac anatomical structure, functional motion, perfusion, and tissue characterization. It holds unique value in the etiological diagnosis, risk stratification, and prognostic assessment of cardiomyopathies, and has become the ideal non-invasive modality for these conditions.

However, data regarding the correlation between CD4+T-lymphocyte counts and cardiac function assessment via CMR in HIV-infected individuals remain scarce. Therefore, this study conducted a case-control analysis using CMR to collect data on myocardial mass, chamber dimensions, volumes, and ejection fractions in HIV patients receiving highly active antiretroviral therapy (HAART). By analyzing CMR data from both HIV and healthy control groups, this study explored the characteristics of cardiac structural and functional changes in HIV-infected individuals. The observed increase in left ventricular myocardial mass in HIV patients suggests an elevated risk of myocardial remodeling.

Statistical results indicated that the Left Ventricular Myocardial Mass (LVMM) in the AIDS group was significantly higher than that in the Asymptomatic HIV group and the Healthy Control group. This finding aligns with previous conclusions stating that "HIV infection is associated with myocardial hypertrophy" [6]. A study reports that HIV infection of cardiac endothelial cells induces the release of pro-inflammatory cytokines, stimulated by Interleukin-1 (IL-1), Interleukin-6 (IL-6), and Tumor Necrosis Factor-alpha (TNF-α)-ultimately triggering chronic vascular inflammation, which subsequently leads to life-threatening endocarditis and cardiac dysfunction [7]. The excessive accumulation of collagen causes left ventricular stiffness and diastolic dysfunction, which are early signs of myocardial fibrosis. Notably, myocardial fibrosis is a critical factor contributing to diastolic and systolic dysfunction, heart failure, and even sudden cardiac death. A meta-analysis involving 1769 participants (1117 HIV-positive patients)—comprising 3 cohort studies and 9 cross-sectional studies—demonstrated that the prevalence and severity of myocardial fibrosis were significantly higher in HIV-infected individuals compared to the uninfected population [8]. In cardiomyocytes infected with HIV-1, the expression levels of microtubule-associated protein 1 light chain

3 (LC3) types I and II are significantly elevated. Studies have confirmed that this high expression of LC3 inhibits autophagy in cardiomyocytes, leading to an accelerated progression of cardiac fibrosis [9].

In this study, the Left and Right Ventricular Ejection Fractions (LVEF and RVEF) in the AIDS group were significantly lower than those in the Asymptomatic HIV group and the Healthy Control group. Additionally, the Right Atrial Anterior-Posterior Diameter was larger in the AIDS group compared to the other two groups. These findings indicate that ventricular pump function is significantly impaired in patients with AIDS. A study by Cetin *et al.* [10] demonstrated that lower CD4+T-cell counts are associated with poorer cardiac pump function. Among HIV carriers with subclinical myocardial injury, the increment in native T1 values was negatively correlated with the nadir CD4 count. Subclinical myocardial inflammation and dysfunction exist in asymptomatic People Living with HIV (PLWH), and a lower nadir CD4 count may serve as a risk factor for subclinical myocardial injury [11].

Furthermore, a study in Nigeria reported that the prevalence of Right Ventricular (RV) dysfunction was 14.5% (95% CI: 10.5% - 19.8%) in HIV-infected individuals, compared to 0% (95% CI: 0.0% - 3.4%) in uninfected participants [12]. Research results indicate that plasma proteomic profiles are significantly enriched in immune checkpoint proteins, TNF signaling pathways, ephrin signaling pathways, and extracellular matrix organization. This reveals potential shared pathways between HIV infection and aging that may lead to an increased risk of heart failure [13]. High viral load has also been associated with both left and right ventricular dysfunction [14] [15].

In our study, the Right Ventricular End-Diastolic Volume (RVEDV) in both the AIDS and Asymptomatic HIV groups was higher than that in the Healthy Control group. When comparing HIV-infected individuals to healthy populations, a lower CD4+T-lymphocyte count was identified as a risk factor for Left Ventricular Diastolic Dysfunction (LVDD) [16].

One study showed that 94 out of 195 HIV patients (48%) exhibited diastolic dysfunction. This cohort also displayed a high prevalence of hypertension, hyperlipidemia, and chronic kidney disease, along with elevated plasma Trimethylamine-N-oxide (TMAO) and choline levels. TMAO levels were associated with parameters reflecting increased left ventricular filling pressures and markers of the innate immune system [17]. Additionally, HIV viral load was positively correlated with ECG Q-wave duration (OR = 0.306; p = 0.038), while a longer duration of HIV infection (≥5 years) was positively correlated with the ST segment interval (OR = 0.270; p = 0.047) [18]. The HIV-1 Tat protein decreases the levels of complex I subunit NDUFA4L2 and cytochrome c (complex III), while simultaneously stimulating complex IV cytochrome c oxidase (Cox-2). These alterations result in downregulated ATP production and upregulated generation of mitochondrial reactive oxygen species (mROS) [19]. Furthermore, expression of HIV Tat in neonatal rat ventricular cells (NRVCs) significantly reduces MCU-mediated mito-

chondrial Ca^{2+} uptake, which subsequently affects the electrophysiological activity of cardiomyocytes and ultimately impairs cardiac contractility [20].

5. Conclusion

Left and right ventricular ejection fractions were lower in HIV-infected individuals, particularly those with AIDS, compared to the Healthy Control group. Conversely, right ventricular end-diastolic volume, right atrial anterior-posterior diameter, and cardiac mass were elevated. These findings suggest that HIV-infected individuals may suffer from right ventricular dysfunction, with more severe impairment observed in patients with AIDS.

6. Limitations

This study is subject to certain limitations. The accuracy and generalizability of the results may be affected by the relatively small sample size, the short duration of the study, and the fact that the data were derived from a single-center cohort.

Ethical Approval

This study was approved by the Ethics Committee of Huizhou Sixth People's Hospital (Approval No. PJ2024MI-KJ009). All participants signed written informed consent forms and authorized the use of their anonymized data for scientific research via the hospital's WeChat mini-program.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper. No financial or personal relationships with other people or organizations could have inappropriately influenced this work.

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