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Unmasking Hypokinetic Non-Dilated Cardiomyopathy in sub-Saharan Africa: a Study of Ethnic Black African Population

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ABSTRACT

Background: *Hypokinetic non-dilated cardiomyopathy (HnDCM) is a less recognized cardiomyopathy phenotype characterized by global left ventricular (LV) systolic dysfunction without significant chamber enlargement. Sub-Saharan Africa lacks substantial data on this specific cardiomyopathy phenotype. To address this knowledge gap, a study was conducted to investigate the clinical, echocardiographic, electrocardiographic, and roentgenographic characteristics of 16 consecutive patients diagnosed with HnDCM in Sub-Saharan Africa.*

Methods: *This prospective study included 16 patients with hypokinetic non-dilated cardiomyopathy (HnDCM) recruited over a 38-month period in Sokoto, Nigeria. Patients underwent clinical assessment, echocardiography, electrocardiography, and chest X-ray. Diagnosis was based on European Society of Cardiology (ESC) working group diagnostic criteria, which include left ventricular (LV) or biventricular global systolic dysfunction (defined as LV ejection fraction <45%) without LV dilatation, and absence of abnormal loading conditions such as (hypertension, valvular heart disease) or coronary artery disease (CAD).*

Results: *The cohort was predominantly middle-aged (mean age 47.8 ± 16.25 years), with a slight female majority (56.25%). All patients presented with heart failure and reduced ejection fraction (<45%), with the majority (56.25%) presenting with left-sided heart failure. A significant proportion exhibited mild to moderate systolic dysfunction (93.75%) and diastolic dysfunction (62.5%). Structural abnormalities were common, including abnormal left ventricular mass index (LVMI) (62.5%) and geometry (68.75%). Significant valvular regurgitation was infrequent, and all patients had normal left ventricular end-diastolic diameter. Electrocardiographic abnormalities were prevalent, including sinus tachycardia (68.75%), ST segment depression (87.50%), T wave inversion (87.50%), prolonged QT (62.50%), and a QRS (RV6/R in I or II or III) voltage ratio of ≤ 3 (93.75%). Chest X-ray revealed cardiomegaly in 56.25% of patients and cardiogenic pulmonary edema in all patients.*

Conclusions: *Hypokinetic non-dilated cardiomyopathy (HnDCM) is a significant cause of heart failure in Sub-Saharan Africa, often overlooked. Increased awareness and targeted research are needed to improve outcomes.*

Keywords

Hypokinetic non-dilated cardiomyopathy, Echocardiography, Electrocardiography, Chest X-ray.

Introduction

Cardiomyopathies are a major cause of global morbidity and mortality [1,2]. Hypokinetic non-dilated cardiomyopathy (HnDCM) remains underrecognized, particularly in Sub-Saharan Africa. This region faces unique challenges, including limited

access to healthcare, which may contribute to delayed diagnosis and management. Cardiomyopathy is a leading cause of heart failure and is often associated with severe cases requiring heart transplantation [1]. It presents as a spectrum of diseases intrinsic to the myocardium, manifesting in various subtypes/phenotypes. Globally, primary (idiopathic) dilated cardiomyopathy is the most prevalent phenotype [2], and is not related to abnormal loading conditions such as valvular heart disease, hypertension, or coronary artery disease [3]. Importantly, this cardiomyopathy may be the leading cause of cardiovascular morbidity and mortality in people of African descent [4,5]. In Sub-Saharan Africa, cardiomyopathy has wide-reaching implications, affecting not only the morbidity and mortality of affected individuals but also the infrastructure, healthcare specialists, and diagnostic modalities required to provide care for these patients [6].

Echocardiography plays a crucial role in the evaluation of cardiomyopathy. It provides timely information on heart structures, wall motion, ventricular systolic and diastolic functions, specific aetiology, and accurate tracking of the disease's pathophysiological abnormalities, aiding in diagnosis and disease definition [3]. However, this essential investigative modality for cardiomyopathy is often unavailable in resource-constrained settings like Sub-Saharan Africa. Traditionally, cardiomyopathy has been classified into dilated and non-dilated (restrictive) forms, with an additional non-dilated subtype known as hypertrophic, which can present as obstructive or non-obstructive [3]. Over the past three decades, the definition and classification of cardiomyopathy have undergone significant transformations [7-9]. Despite these changes, echocardiographic morpho-functional classification of cardiomyopathy [10], remains a practical approach, especially in resource-constrained settings. However, a limitation of this classification is its failure to account for a group of cardiomyopathy patients who exhibit normal or near-normal LV chamber diameters with global hypokinesia and LV systolic dysfunction. This oversight has led to growing interest in this patient group over the past three decades, as reported in several studies [11-13]. In response, the ESC working group recently proposed a new distinct category of cardiomyopathy, HnDCM, based on echocardiographic morpho-functional findings of LV non-dilatation (LV internal diameter in diastole <56 mm), global hypokinesia, and systolic dysfunction (LV ejection fraction <45%), with a probable genetic aetiology for early diagnosis and prevention [14].

The global prevalence of HnDCM a distinct phenotype of cardiomyopathy is 0.9 to 1.9% [15], comprising 35% of DCM cases. Approximately 24% of HnDCM patients progress to DCM[16]. Given these observations, HnDCM is considered an early presentation of DCM, characterized by relatively mild clinical features and a better prognosis [16]. However, in some cases, the prognosis can be similar to DCM, despite non-LV dilatation, as reported by Karen et al. [11]. Although the prognosis of congestive cardiomyopathy is more closely linked to increased LV dimensions.

To our knowledge, there is a paucity of data on this distinct phenotype of cardiomyopathy in sub-Saharan Africa. Therefore, this study aims to describe the clinical, echocardiographic, electrocardiographic, and roentgenographic profiles of HnDCM in a Sub-Saharan African community. By increasing the understanding of this cardiomyopathy phenotype among the general population and clinicians, we hope to improve awareness, early diagnosis, prevention, and treatment, thereby averting misdiagnosis and fatal clinical consequences.

Methods

This study was conducted in accordance with the principles and guidelines of human research outlined in the Declaration of Helsinki [17]. Ethical approval for the study was obtained from the Institutional Ethics Review Committee of Medi-Stop Clinical Diagnostics Sokoto (MCD/ADM/Vol.II/2021/24), Usmanu Danfodiyo University, Sokoto (UDUS/C/HREC/11/2021), and Specialist Hospital Sokoto (SHS/SUB/133/VOL.1). All participating patients provided written informed consent. This prospective study involved 16 consecutive patients aged 18 years and older who presented to the aforementioned health facilities for clinical, echocardiographic, electrocardiographic, and roentgenographic evaluation over a 38-month period. The 16 patients met the diagnostic criteria for hypokinetic non-dilated cardiomyopathy (HnDCM) as defined by the ESC Working Group [14]. Briefly, these criteria include: left ventricular (LV) or biventricular global systolic dysfunction (defined as LVEF <45%), non-LV dilatation (LV internal diameter in diastole <56 mm), and global hypokinesia, not attributable to abnormal loading conditions (such as systemic hypertension, valvular heart disease) or coronary artery disease (CAD) [14]. At enrolment, a detailed clinical history was obtained from each patient, including symptoms suggestive of left-sided and right-sided heart failure and a family history of similar illnesses. Each patient underwent a meticulous physical examination, relevant laboratory investigations, and diagnostic imaging. Patients with abnormal loading conditions such as systemic hypertension, valvular heart disease (as determined by history, examination, and echocardiography), acute coronary syndrome (ACS), ischemic cardiomyopathy (as indicated by past history, history suggestive of myocardial infarction, stable or unstable angina at presentation, significant ST elevation or depression, cardiac markers, and pathological Q wave on ECG, scars or regional wall motion abnormalities on echocardiography, or evidence of significant coronary artery disease on coronary angiography), and specific cardiomyopathies (such as diabetic, tachycardia-induced, thyrotoxic, drug-induced, alcoholic, obesity-induced, hypocalcemia-induced reversible hypokinetic non-dilated cardiomyopathy, peripartum cardiomyopathy [18], and LV non-compaction cardiomyopathy) were excluded from the study. Subjects with LV systolic dysfunction due to congenital heart disease, chronic kidney disease, chronic liver disease, and suspected acute myocarditis were also excluded.

At the time of clinical presentation, each patient's New York Heart Association (NYHA) functional class was determined, and anthropometric measurements (weight, height, body mass index [BMI], and body surface area [BSA] calculated using

the Mosteller formula [19] were recorded. A thorough physical examination was performed, including pulse examination, blood pressure measurement using a standard protocol with an Accoson mercury sphygmomanometer [20], and assessment for jugular venous distension, displaced apex beat, heart sounds (S3 gallop, variability of S1, loud P2), murmurs, lung sounds (bibasilar crackles), pedal oedema, hepatomegaly, and ascites. In addendum thorough general and systemic examination were carried out on each patient for the study.

Echocardiography

A transthoracic echocardiographic examination was performed in the supine and left lateral positions using a Sonoscape SSI-5000 machine equipped with a 1-6 MHz transducer. All patients underwent detailed 2D-guided M-mode imaging according to the recommendations of the American Society of Echocardiography (ASE) [21]. Measurements of the left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD), interventricular septal thickness in diastole (IVSTd), and left ventricular posterior wall thickness in diastole (LVPWTD) were obtained from the parasternal long-axis and short-axis views, measured at the tips or just below the tips of the mitral valve leaflets, as recommended by the ASE [21]. Left ventricular mass (LVM) was calculated using the Devereux modified cubed formula [22], and indexed to body surface area (BSA) [19], to obtain left ventricular mass index (LVMI). Left ventricular hypertrophy (LVH) was defined according to gender-specific threshold values [21]. Relative wall thickness (RWT) was determined as 2 × PWTD (posterior wall thickness, diastolic) / LVEDD (left ventricular end-diastolic dimension). RWT was considered increased when >0.42 [21].

RWT and left ventricular mass index (LVMI) were used to characterize LV geometry as follows: (1) Normal LV geometry: normal LVMI and normal RWT; (2) Concentric LV remodelling: (normal LVMI and increased RWT); (3) Eccentric LV hypertrophy: (increased LVMI and normal RWT); (4) Concentric LV hypertrophy: (increased LVMI and increased RWT [21]. Left ventricular end-diastolic volume (LVEDV) and left ventricular end-systolic volume (LVESV) were calculated using the Teichholz method [23], and indexed to body surface area (BSA) [19].

Left ventricular ejection fraction (LVEF) was assessed using the Teichholz formula [23]. Right ventricular internal diameter in diastole (RVIDd) at the base and right atrial internal dimension (RAID) at the minor axis in the apical four-chamber view were determined and indexed to body surface area (BSA) [19,21]. Left ventricular regional and global wall motion abnormalities were also assessed. Left ventricular diastolic function was assessed using spectral Doppler echocardiography to measure E/A ratio, E deceleration time (DT), and isovolumic relaxation time (IVRT), and graded according to established criteria [24]. The presence and severity of valvular regurgitation across heart valves were semi-quantitatively assessed using colour flow Doppler echocardiography, with regurgitant jet (RJ) area measured in the apical four-chamber view, as recommended by the ASE [25]. Valvular regurgitation was graded as mild, moderate, or severe based on RJ area criteria established by the ASE [25]. Other echocardiographic findings, including intramural clot, ventricular trabeculations, valvular leaflet thickness/calcification, reduced valvular area, pericardial effusion, interventricular/interatrial septal defect, and pulmonary arterial pressure, were also evaluated and documented.

Electrocardiography (ECG)

A standard 12-lead electrocardiogram (ECG) was performed on each patient, including a long rhythm strip in lead II, following the recommendations of the American Heart Association (AHA) [26], and standard lead and instrument specifications. ECG parameters, including heart rate, rhythm, PR interval, QRS duration/morphology, axis deviation, and QT interval, were measured and recorded. Atrial and ventricular arrhythmias (such as supraventricular tachyarrhythmias, bradyarrhythmia's, ventricular arrhythmias, heart blocks, and premature contractions) were also documented.

Chamber Enlargement (atrial): (1) Right atrial enlargement (RAE) was defined as a peaked P wave with an amplitude ≥ 2.5 mm in leads II, III, and aVF; (2) Left atrial enlargement (LAE) was defined as a notched P wave with a duration ≥ 0.12 seconds or a P-terminal force in V1 ≤ -0.04 mm; (3) Bi-atrial enlargement was defined as a large diphasic P wave in V1 with an initial positive deflection > 1.5 mm and a negative terminal deflection ≥ 1 mm in height and 0.04 seconds in duration.

Ventricular Hypertrophy: To diagnose left ventricular hypertrophy (LVH), the Sokolow-Lyon or Araoye criteria were employed. The Sokolow-Lyon criteria involve calculating the sum of the S wave in V1 and the R wave in V5 or V6, which must exceed 35 mm [27]. The Araoye criteria, however, require the sum of the S wave in V2 and the R wave in V5 or V6 to be greater than 35 mm for females or 40 mm for males [28]. Right ventricular hypertrophy (RVH) was defined by the presence of one or more of the following criteria: (1) R wave in V1 > 6 mm; (2) R/S ratio in V1 > 1; (3) R/S ratio in V5 or V6 < 1; (4) R wave in V1 + S wave in V5 or V6 > 10.5 mm; (5) qR complex in V1. Combined ventricular hypertrophy was defined as meeting the criteria for both LVH and RVH. The ratio of R-wave in V6 to the maximum R-wave in leads I, II, and III (RV6/Rmax) was calculated [29].

ST-T Changes: ST-segment and T-wave abnormalities were also noted. Supraventricular tachyarrhythmias (SVTs), bradyarrhythmia's, ventricular arrhythmias, heart blocks, and premature contractions (atrial, junctional, and ventricular) were recorded.

Chest Radiograph

A posteroanterior chest radiograph was performed on all participants to assess cardiac silhouette, cardiothoracic ratio (CTR), and lung parenchyma. The following abnormalities were evaluated: cardiomegaly, aortic arch enlargement, alveolar/interstitial edema, upper lobe diversion, prominent vascular

markings, bat-wing appearance, pleural effusion, and parenchymal abnormalities.

Other Relevant Investigations

Hematological parameters (hemoglobin), biochemical parameters (fasting blood sugar, fasting lipid profile, serum urea, electrolytes, and creatinine) were determined, and sociodemographic, clinical, echocardiographic, electrocardiographic, and roentgenographic findings were recorded for each patient.

Inclusion Criteria

The study included patients aged 18 years and older who met the diagnostic criteria for hypokinetic non-dilated cardiomyopathy (HnDCM) as defined by the ESC Working Group [14]. This criterion includes left ventricular (LV) or biventricular global systolic dysfunction (LVEF <45%) without LV dilatation, not attributable to abnormal loading conditions (such as systemic hypertension, valvular heart disease) or coronary artery disease (CAD) [14].

Exclusion Criteria

Patients who did not meet the ESC Working Group diagnostic criteria for hypertrophic non-obstructive cardiomyopathy (HnDCM), those who died before completing the study, and those who declined participation were excluded [14].

Statistical Analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS) software, version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to analyse both continuous and categorical variables. Mean and standard deviation were calculated for quantitative variables, while qualitative variables were expressed as frequencies, proportions, or percentages and presented in tables or graphs.

Results

Socio-Demographic Characteristics and Anthropometric Measures

The mean age of the study population was 47.8 ± 16.25 (ranging from 22-80years). HnDCM was more preponderant in females with M:F ratio of 1:1.2. Most of the participants were uneducated (no formal education). Most the participants are unemployed especially the females and of low socioeconomic status. None of the participants reported smoking and/or use of alcohol. The mean height and BMI of the participants were within normal limits (>1.50m and >23kg/m^2); (see Table 1).

Clinical History and Physical Examination Findings

The mean duration of symptoms prior to presentation was 4.5 ± 2.4 weeks. They presented in NYHA class II (31.25%), III (37.50%) and IV (31.25). S_3 gallop was found in 87.50% of the patients while raised JVP was seen in 43.75% of patients at presentation. Most patients presented with left-sided heart failure (56.25%). Clinically only (12.5%) had mitral regurgitant murmur while tricuspid regurgitant murmur was found in (6.25%) of the patients. One patient had complication probably AF related Cardio-embolic stroke; (see Table 2).

Table 1: Show sociodemographic characteristics and Anthropometric measures of the HnDCM patients.

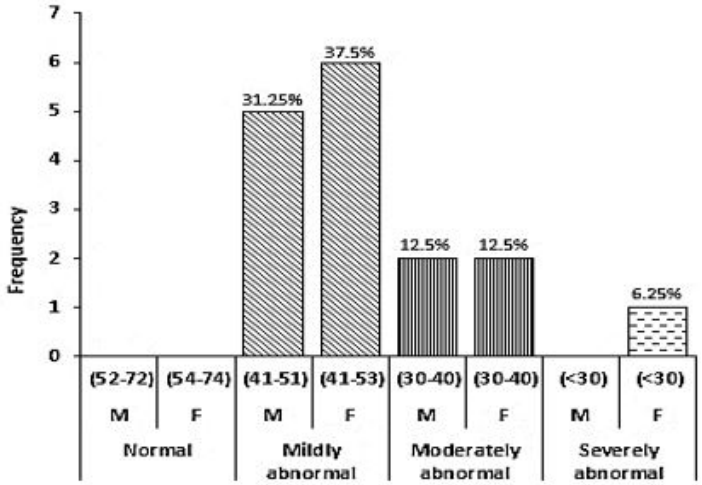
Parameters	Frequency (%)
Gender (n=16)	
Male	7 (43.75)
Female	9 (56.25)
Marital Status (n=16)	
Single	1 (6.25)
Married	13 (81.25)
Widow	2 (12.50)
Educational Status (n=16)	
Quranic	14 (87.50)
Secondary	1 (6.25)
Tertiary	1 (6.25)
Occupation (n=16)	
Unemployed	9 (56.25)
Farmer	2 (12.50)
Trader/Business	4 (25.00)
Civil servant	1 (6.25)
Religion (n=16)	
Islam	100 (100)
Tribe (n=16)	
Hausa/Fulani	15 (93.75)
Others	1 (6.25)
Anthropometric measures	Mean ± SD
Weight (kg) ± SD	64.3 ± 11.4
Height (M) ± SD	1.6 ± 0.1
Body Mass Index (BMI) kg/m^2 ± SD	23.9 ± 3.6

Table 2: Show relevant clinical history and physical examination findings of HnDCM patients.

Clinical Parameters	Mean ± SD
Pulse Rate ± SD	118.8 ± 13.3
Systolic blood pressure (SBP) ± SD mmHg	110.6 ± 12.4
Diastolic blood pressure (DBP) ± SD mmHg	72.5 ± 10.6
Pattern ventricular heart failure; at presentation (n=16)	**Frequency (%)**
Biventricular heart failure (BVHF)	7 (43.75)
Left ventricular heart failure (LVHF)	9 (56.25)
Point of clinical evaluation (n=16)	
Out-patient	12 (75.0)
In-patient	4 (25.0)

Echocardiographic Profile of HnDCM Patients

All the patients had LVEF < 45% with majority having mild to moderate LV systolic dysfunction in (93.75%) of patients and severe LV systolic dysfunction observed in (6.25%) a female; (see Figure 1). LV diastolic dysfunction was observed in (62.5%) of patients (see Figure 2). (50%) of the patients had abnormal LVEDVI and (87.5%) had abnormal LVESVI. Abnormal LVMI was observed in (62.5%) of the patients; (see Figure 3). LV



geometry was abnormal in (68.75%) of patients; (see Figure 4). Mitral and tricuspid regurgitation was observed in all the patients. None of the patient had Aortic regurgitation; (see Table 3).

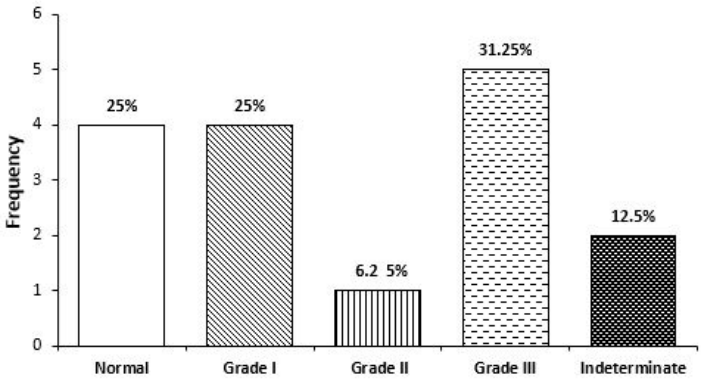
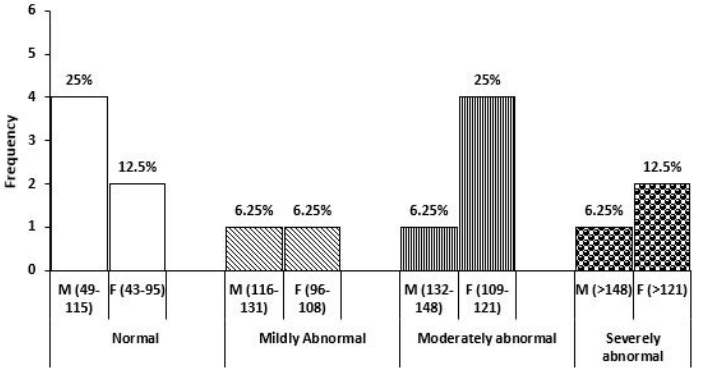


Figure 1: Severity of LV systolic dysfunction using ejection fraction



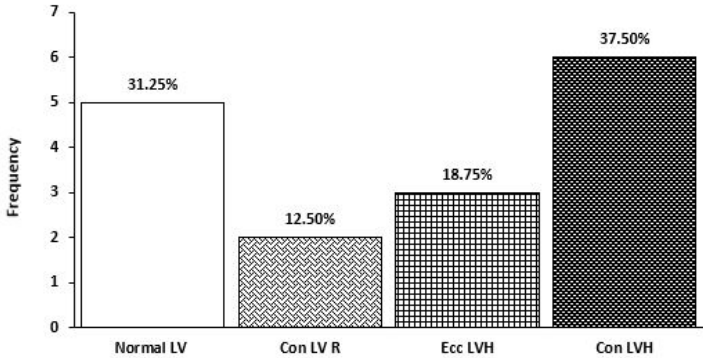
(EF%) of the patients.

Figure 2: Grades of LV diastolic dysfunction (LVDD) in HnDCM patients.

Figure 3: Show severity of left ventricular hypertrophy using LVMI (g/m^2) by linear method in HnDCM patients.

Electrocardiographic Features of Patients

The mean HR was (112.2 ± 18.9bpm), PR interval was (135 ± 31.9ms) and mean QRS duration was (91.5 ± 14.3ms). Normal global QRS amplitude was observed in (93.75%) of the patients with QRS voltage ratio ≤ 3. The most common ECG abnormalities detected were sinus tachycardia (68.75%), ST depression (87.5%), T wave inversion (87.50%) and prolonged QTc (62.50 %). Extremely rare ECG abnormalities observed were LVH (25.0%),



LAE (12.5%), RAE (6.25%), Atrial ectopic (6.25%), Atrial flutter (12.50%), Atrial fibrillation (6.25%), LAHB (12.5%) and T wave flattening (6.25%); (see Table 4).

Figure 4: Show pattern of LV geometry in HnDCM patients.

Table 3: Show echocardiographic profile of HnDCM patients.

Variables	Mean ± SD
Left atrial internal dimension (LAID) mm ± SD (mm)	
Male	40.5 ± 8.7
Female	35.4 ± 4.8
Right atrial internal dimension (RAID) mm ± SD (mm)	
Male	36.0 ± 2.9
Female	35.5 ± 4.3
Left Ventricular end-diastolic diameter (LVEDd) ± SD (mm)	
Male	50.7 ± 4.6
Female	49.4 ± 3.8
Right ventricular internal dimension (RVID1) A4CHV ± SD (mm)	
Male	26.8 ± 1.2
Female	26.8 ± 2.4
Mean pulmonary arterial pressure (MPAP) of the HnDCM patients	35 ± 5.8
	Frequency (%)
Left ventricular global hypokinesia	16 (100)
Left atrial thrombus	1(6.5)

Valvular regurgitation	Mild	Moderate	Severe
Pulmonary	16	-	-
Mitral	13	3	-
Tricuspid	10	4	2

Roentgenographic Features of Patients

The chest radiograph shows varying degree of cardiomegaly with cardiothoracic ratio (CTR) between (0.51to 0.6) in (56.25%) and only (43.75%) had normal CTR ratio. All the patients had

radiological evidence of cardiogenic pulmonary edema of upward blood diversion and hilar prominent vascular markings at presentation; (see Table 5).

Table 4: Electrocardiographic profile of the HnDCM patients.

Parameters	Frequency (%)
Prolonged QTc ms (n=16)	
Male	
Prolonged QTc (>440ms)	6(37.50)
Normal QTc	1(6.25)
Female	
Prolonged QTc (>460ms)	4(25.00)
Normal QTc	5(31.25)
QRS Axis (n=16)	
Normal	12(75.00)
LAD	4(25.00)
QRS Amplitude mm (n=16)	
Normal global QRS voltage	15(93.75)
Low global QRS voltage	1(6.25)
QRS voltage ratio RV6/ maximum R in lead I, II, III (lead with maximum R)	
RV6/ I, II, III ratio ≤ 3	15(93.75)
RV6/I, II, III ratio ≥ 3	1(6.25)
Sinus Rhythm	2(12.50)

Table 5: Show roentgenographic (Chest Xray) features of the HnDCM patients.

Parameters	Frequency (%)
Cardio-thoracic Ration (CTR): (n=16)	
0.42-0.5	7(43.75)
0.51-0.6	9(56.25)
Upward blood diversion in the upper lung fields (Cephalization of pulmonary vessels) and prominent hilar vascular markings (n=16)	16(100)

Discussion

The key findings of this study highlight the importance of recognizing HnDCM in the context of heart diseases prevalent in Sub-Saharan Africa. The primary findings include: (1) All HnDCM patients presented with heart failure; (2) HnDCM was more prevalent among females; (3) The majority of patients with HnDCM were in their fifties; (4) HnDCM was particularly common in individuals from low socioeconomic backgrounds and with limited education. None of the female patients were gainfully employed; (5) Patients with HnDCM exhibited significant left ventricular (LV) structural remodelling, including LV hypertrophy and abnormal LV geometry, as well as diastolic dysfunction; (6) A considerable number of patients with HnDCM had prolonged QT intervals, ST-T changes, and abnormal chest X-ray findings.

The finding of HnDCM among patients of low socioeconomic status in the northwestern region of Nigeria can be linked to various socioeconomic challenges. This region is characterized by low formal education, maternal economic deprivation, negative socio-cultural influences, and widespread poverty. These factors support Canadian sociologist Dennis Raphael's assertion that poverty is a stronger predictor of heart disease than traditional risk factors such as obesity, high cholesterol, stress, and smoking [30]. Consequently, poverty may be a key factor influencing the occurrence of HnDCM in this region. Additionally, patients often delay seeking medical help, typically experiencing an average of four weeks of symptoms before diagnosis. This delay is attributed to a lack of awareness about the disease among the largely uneducated population and inadequacies in Nigeria's healthcare financing system, which necessitates out-of-pocket expenses for healthcare access [6]. As a result, many patients turn to inexpensive traditional healers, especially when faced with diseases of unknown etiology. However, the life-threatening nature of dyspnea, a hallmark symptom of HnDCM, compels patients to seek hospital treatment only when traditional remedies fail. These factors likely contribute to the late presentation of HnDCM patients for diagnosis. Clinically, a third heart sound (S3 gallop), a hallmark sign of left ventricular dysfunction, was observed in the majority of HnDCM patients. Correspondingly, mitral and tricuspid regurgitant murmurs were uncommon in HnDCM. This rare finding of functional regurgitant murmurs in HnDCM is likely due to the non-dilatation of the ventricular chambers and atrioventricular valve annuli. Cardioembolic stroke is infrequent among HnDCM patients, with only one case of a probable atrial fibrillation-related stroke, which aligns with the rarity of atrial fibrillation in this group. Despite all patients showing left ventricular global hypokinesia on echocardiography, no intramural thrombus was found at diagnosis. The findings from this study revealed that all HnDCM patients exhibited non-left ventricular (LV) dilatation, which aligns with the revised ESC working group diagnostic criteria for HnDCM [14]. However, this contrasts with some earlier research [11-13], including a recent study by Marta Gigli et al. [16], which noted mild LV dilation in certain cases. All participants had a left ventricular ejection fraction (LVEF) below 45%, consistent with both the ESC criteria for HnDCM [14], and Marta Gigli et al. study [16]. Most patients demonstrated mild to moderate LV systolic dysfunction, with one female patient experiencing severe LV systolic dysfunction. Notably, three-quarters of the patients also had LV diastolic dysfunction as indicated by spectral Doppler evaluations. The study found that left ventricular end-diastolic volume index (LVEDVI) and left ventricular end-systolic volume index (LVESVI) are reliable independent indices for assessing global systolic function. Specifically, LVEDVI was abnormal in half of the patients, while the majority displayed abnormal LVESVI, corroborating Marta Gigli et al. Findings [16]. Additionally, all patients showed LV global hypokinesia, a significant observation in the context of HnDCM [14].

Hypokinetic non-dilated cardiomyopathy (HnDCM) is a subset of dilated cardiomyopathy (DCM) [16]. HnDCM like dilated cardiomyopathy, regardless of aetiology or type, is associated with significant cardiac structural pathological remodelling [31]. This structural remodelling involves a complex interplay of molecular, cellular, and interstitial changes following injury [31], affecting the heart's shape, size, geometry, mass, and function [31]. This often leads to poor outcomes, including ventricular dysfunction

and malignant arrhythmias. Echocardiography is the primary non-invasive tool for assessing structural pathological remodelling, including left ventricular hypertrophy (LVH), changes in ventricular size, and LV geometry [31]. Using echocardiography LVH, is defined as an abnormal left ventricular mass index (LVMI) and geometric patterns [32], is a crucial indicator for diagnosing cardiovascular disease and has significant clinical implications [33,34]. In HnDCM, as in other structural heart diseases, LVH (abnormal LVMI and pattern of LV geometry) is likely influenced by genetic factors, age of onset, initial cause, neurohormonal activation, and differences in hemodynamic mechanisms, along with LV systolic and diastolic dysfunctions [33-35].

In this study, we observed significant LV structural pathological remodelling (LVH and abnormal pattern of LV geometry) in the majority of HnDCM patients without significant changes in LV size. This notable finding of LVH and abnormal patterns of LV geometry in HnDCM patients, without significant changes in LV size, was also observed in a recent study by Marta Gigli et al. [16]. This suggests that such structural pathological remodelling (LVH and abnormal pattern of LV geometry) could serve as strong independent predictors of disease progression, morbidity, and mortality [32,33,36], in HnDCM, unless prevented by appropriate treatment.

The color Doppler echocardiography findings in this study indicated varying degrees of regurgitation in the pulmonary, mitral, and tricuspid valves. Specifically, three patients exhibited moderate mitral regurgitation, while four had moderate tricuspid regurgitation, and two experienced severe tricuspid regurgitation. Notably, significant functional valvular regurgitation is uncommon in HnDCM. This may be attributed to the non-dilatation of the ventricular chambers and atrioventricular valve annuli. The moderate to severe tricuspid regurgitation observed in some patients could also be attributed to pulmonary arterial hypertension. Although electrocardiogram (ECG) is a widely accessible, cost-effective diagnostic and prognostic tool, despite being considered non-specific for cardiomyopathy [37], it plays a crucial role as a first-line screening modality in identifying ECG "red flags" associated with sudden cardiac death in cardiomyopathy [37], especially in resource constrained settings. In this study of patients with HnDCM, most showed normal PR intervals, QRS duration and amplitude, and axis. However, left axis deviation was noted in 25% of cases. The predominant ECG abnormalities in HnDCM included sinus tachycardia, ST-T changes, and prolonged QT. While HnDCM is a subtype of dilated cardiomyopathy (DCM), the study found a QRS voltage ratio of ≤ 3 in most HnDCM patients, which contrasts with the typical ratio of ≥ 3 in DCM due to substantial myocardial loss, fat infiltration, LV dilatation, and significant LV myocardial fibrosis [29,36,38-40]. This lower voltage ratio in HnDCM is likely attributed to minimal myocardial loss, fat infiltration, low levels of diffuse left ventricular (LV) fibrosis, and non-LV dilatation. Atrial arrhythmias and enlargement were rare in HnDCM, likely due to the infrequent occurrence of atrial enlargement, which usually promotes secondary electrical remodelling leading to conditions like atrial fibrillation or flutter. Similarly, ventricular arrhythmias and ECG-detected left ventricular hypertrophy (LVH) were also uncommon in HnDCM, even though index patients were not followed up in this study. Based on these findings, we can conclude that atrial arrhythmias with hemodynamic instability and sudden cardiac death may rarely occur in HnDCM. However, the notable prevalence of prolonged QT syndrome in these patients raises concerns, as it may increase the risk of torsades de pointes and subsequent ventricular fibrillation, potentially leading to sudden cardiac death. In summary, this study indicates that while ECG abnormalities in HnDCM are generally mild, the presence of prolonged QT poses a significant risk for life-threatening ventricular arrhythmias, despite the low incidence of other serious cardiac arrhythmias. The chest X-ray (CXR) is the most frequently used imaging technique for detecting cardiomegaly [41], particularly in resource-limited settings. Regardless of the underlying cause, cardiomegaly observed on CXR is an independent predictor of increased mortality and poor prognosis, especially among elderly patients [42], and probably in patients from resource-limited settings. The interpretation of cardiomegaly on CXR is often subjective and depends on the interpreter's judgment [43]. Previous research by Clerk et al. [42], indicated that radionuclide ventriculography and echocardiography provide more accurate assessments of left ventricular (LV) size and function compared to CXR [44], which has relatively low diagnostic accuracy for cardiomegaly.

In the current study, most patients with HnDCM exhibited cardiomegaly with a cardiothoracic ratio (CTR) between 0.51 and 0.6. This finding may be attributed to structural pathological changes in the LV, such as left ventricular hypertrophy (LVH), abnormal left ventricular end-systolic and end-diastolic volumes (LVESVI and LVEDVI), and possibly the presence of pericardial fat pads without significant enlargement of the ventricular chambers. The results suggest that while cardiomegaly on CXR is prevalent among HnDCM patients, the CTR rarely exceeds 0.6. Additionally, signs of cardiogenic pulmonary oedema are commonly seen on CXR in these patients, which aligns with the fact that all participants presented with heart failure.

The clinical implications of this study that merit consideration are as follows: (1) Despite non-LV dilation in HnDCM, this phenotype of cardiomyopathy is characterized by significant LV structural pathological remodeling (LVH and abnormal pattern of LV geometry). This pathological structural remodelling may predict progressive LV dysfunction if not promptly identified and managed appropriately; (2) Prolonged QT intervals are common in HnDCM, which can lead to life-threatening cardiac arrhythmias and sudden cardiac death; (3) In our region, HnDCM occurs more often in females, and the prognosis may be worse due to unemployment, illiteracy, and socioeconomic factors; (4) HnDCM is more common in patients of low socioeconomic status, which may result in delayed hospital presentation, diagnosis, and poor prognosis.

Conclusions

Hypokinetic non-dilated cardiomyopathy, is a significant but often ignored cause of heart failure in Sub-Saharan Africa. Despite non-

LV dilatation in HnDCM, we clearly demonstrated significant LV structural pathological remodelling LVH (abnormal LVMI and pattern of LV geometry), LV diastolic dysfunction, abnormal chest radiograph, significant ST-T changes, QT prolongation, and QRS voltage ratio ≤ 3 in HnDCM at diagnosis. Thus, significant LV structural pathological remodelling (LVH) and prolonged QT in HnDCM may be associated with progressive ventricular dysfunction and poor prognosis. This study serves as a call to action for healthcare professionals and researchers to focus on HnDCM and improve the recognition and treatment of this condition to enhance patient outcomes in Sub-Saharan Africa. More robust multi-center prospective and longitudinal studies are needed to further buttress our findings and enrich the existing literature.

Limitations of the Study

Due to cost constraints, limited facilities, and ethical considerations, myocardial biopsy, genetic studies, tissue Doppler imaging, and patient follow-up studies were not feasible. Coronary angiography was not performed on all enrolled patients due to high costs, but we rigorously excluded ischemic heart disease. Cardiac magnetic resonance (CMR) was considered as a reference non-invasive modality for the diagnosis of acute myocarditis, however is not available. Despite this limitation, we try to rule it out through history, examination and other relevant focus investigations.

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