ORIGINAL ARTICLE

Right ventricular function in patients with heart failure in a cardiac clinic in Southwest Nigeria

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ABSTRACT

Background: Right ventricular (RV) function is an important entity in heart failure. Patients with RV dysfunction (RVD) have poorer prognosis and exercise tolerance than those with preserved RV systolic function. Tricuspid annular plane systolic excursion (TAPSE) has been proposed as a simple and reproducible parameter for the qualitative assessment of RV systolic function/ejection fraction (EF). This study aims at describing RV function/RVD among heart failure patients in a specialized cardiac facility in Southwestern Nigeria. **Materials and Methods:** One hundred and thirty-two patients with clinical diagnosis of heart failure were recruited into the study between June 2011 and December 2014. Baseline data, laboratory investigations, electrocardiography, and echocardiography were taken for the participants. RV function was assessed with TAPSE. Statistical analysis was done using Statistical Package for Social Sciences 16.0 (Chicago Ill. USA). $P < 0.05$ was considered statistically significant. **Results:** The mean age of study participants was 62.1 ± 14.2 years. RV systolic dysfunction (TAPSE <20 mm) was found in 86 (65.2%) of all patients while moderate-to-severe RVD (TAPSE <15 mm) was found in 26 (19.7%) patients. Those with RVD are more likely to be older and had a larger left ventricular internal diastolic dimension than those without RVD. Systolic blood pressure, diastolic blood pressure, and EF were significantly lower among patients with RVD than those with normal RV function. **Conclusion:** RVD is common and is associated with more advanced heart failure and possibly worse prognosis among Nigerians with heart failure. Screening for RVD is encouraged to identify and aggressively treat to reduce the associated increased mortality.

Keywords: Clinical correlates, heart failure, prevalence, right heart, right ventricular dysfunction

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INTRODUCTION

The prevalence of heart failure continues to increase worldwide and accounts for a major part of healthcare expenditure in developed and developing economies.[1,2] The increasing burden of risk factors for heart failure seems to be a major driving force for the increase in prevalence of heart failure.[3] While heart failure is a syndrome which may be inclusive of symptoms of both left and right heart failure, less emphasis is placed on the right ventricular (RV) function in heart failure patients.[4] Little attention is also placed on the methods of detecting RV dysfunction (RVD) and the determinants and prognostic impacts of RVD in heart failure patients.[5] The right ventricle is a less muscular part of the heart and is restricted in that it only pump blood to the lungs, and its function and importance cannot however be overemphasized.[6] The right ventricle is affected and contributes to a number of disease processes. We have shown that the right ventricle is equally affected in hypertension considering the diastolic parameters among Nigerians.[7,8] The RV is exposed to similar pressure, volume,

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and chemical changes associated with most cardiovascular diseases.[8,9] Various adaptive mechanisms which occur in left heart disease will eventually affect the right heart due to the fact that they shared similar interphase in the interventricular septum. While there are many markers of RV function, most reports on heart failure are silent on the contribution of right heart dysfunction in patients with heart failure.[10] It is worthy of note that an incompetent RV will obviously lead to poor biventricular function even at the expense of increased left ventricular (LV) adaptations.

The measurement of RV function is not as easy as that of the left heart for many reasons. First, the anatomy of the right heart makes it exclusive and practically difficult to assess unlike the left heart. Furthermore, it is a lower pressure system and it is not universally agreed the most effective way to assess its function and dysfunction.[11] It is also difficult to measure due to the interplay between intrinsic myocardial performance and RV loading conditions.[12] Markers such as tricuspid annular plane systolic or diastolic excursion (TAPSE), RV ejection fraction (EF), RV index of myocardial performance (Tei index), right atrial size, and RV dilatation among others are useful in assessing for RVD.[13-15] This study therefore aimed to determine the prevalence of RVD using the tricuspid annular plane systolic excursion in patients with heart failure and also their associated clinical correlates in a private cardiac clinic in Southwest Nigeria.

MATERIALS AND METHODS

This was a cross-sectional study. All consecutive patients with clinical diagnosis of heart failure seen between May 2011 and December 2013 were recruited into the study. The study center is Goshen Heart Clinic, Osogbo, Nigeria, a private specialized cardiac clinic in Southwest Nigeria. The diagnosis of heart failure was made using standardized Framingham's criteria.[16] They include all patients with both heart failure with preserved EF (HFPEF) and heart failure with reduced EF (HFREF) who presented within the study period. The clinical records were reviewed for demographic, clinical, and laboratory data. All patients in the study had 12-lead resting electrocardiography (ECG) and echocardiography.

Information obtained from the clinical records includes age, gender, occupation, clinical features of heart failure, drug history, history of hypertension and diabetes mellitus, smoking history, alcohol history, and duration of symptoms. Height, weight, waist circumference, average systolic blood pressure (SBP) and diastolic blood pressure (DBP), and pulse rate were obtained. ECG was done using ECG 1200 by Contec Medical Systems, China. Echocardiography was performed using the HP Sonos 2500 by HP Inc., USA, with a 3.5 MHz probe. All echocardiography were performed according to the standardized American Society of Echocardiography guideline on quantification and evaluation of systolic and diastolic parameters and chambers assessment.[14,15] The following parameters were obtained: LV internal dimension in diastole, LV internal dimension in systole, LV posterior and septal wall dimension in diastole, EF, fractional shortening, left atrial dimension (LAD), RVD, aortic root dimension, and aortic cusp separation. Global and regional assessment for wall motion abnormalities were made visually and reported. The ECG was interpreted by the author blinded to the clinical data of the patients. Parameters such as heart rate, rhythm, QRS axis, PR interval, and QTc were obtained. LV hypertrophy was defined using the Sokolow Lyon-criteria.[16,17] Fasting blood sugar, lipid profile including high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, total cholesterol, and triglycerides were obtained using a rapid point of care, strip-based test LipidPro by Infopia Ltd, Korea.

RVD was defined by the tricuspid annular plane systolic excursion (TAPSE) as TAPSE <20 mm. Moderate-severe RVD was defined as TAPSE <15 mm. Right atrial and RV dimensions were also compared between the groups.

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 16.0, Chicago IL, USA. Numerical data were summarized as mean ± standard deviation. Qualitative data were summarized as frequency and percentages. Student's *t*-test, analysis of variance, and Chi-square test were used as appropriate to determine differences between groups. $P < 0.05$ was considered statistically significant.

RESULTS

The clinical, demographic, and echocardiographic characteristics of study participants are as shown in Table 1. The mean age of the participants was 62.1 ± 14.2 years and consisted of 76 males (57.6%). The mean SBP and DBP were 136.6 ± 28.6 mmHg and 83.2 ± 17.6 mmHg, respectively. The LV internal diastolic dimension, LV chamber wall dimensions, and other related echocardiographic findings are as shown in Table 1. Mean TAPSE was 18.4 ± 4.8 mm. About one-third of them (31.1%) were in the New York Heart Association Stage III/IV at diagnosis. Most of them have comorbidities/etiological factors such as hypertension in 78%, diabetes mellitus in 17.4%, history of past or present smoking in 12.2%, and alcohol intake documented in 15.2% of study participants. Most of them were on at least angiotensin receptor blockers or angiotensin-converting enzyme inhibitors (67.4%) and aldosterone antagonists (70.5%). Fewer were on statins (9.8%) and beta-blockers (9.1%). Mild RVD defined as TAPSE 15–19 mm was documented in 60 (45.5%) while moderate-severe RVD as defined by TAPSE <15 mm was documented in 26 (19.9%) of study participants.

Table 1: Clinical, demographic, and other characteristics of study participants and relationship with tricuspid annular plane systolic excursion

Variable	Value
Age (years)	62.1±14.2
Males, *n* (%)	76 (57.6)
Mean SBP (mmHg)	136.6±28.6
Mean DBP (mmHg)	83.2±17.6
LVDD (mm)	49.0±11.9
EF (%)	47.6±11.7
IVST (mm)	12.8±2.4
PWTD (mm)	12.6±1.9
RVD (mm)	29.5±5.4
LAD (mm)	45.9±9.2
TAPSE (mm)	18.4±4.8
LVM (mm)	146.8±57.1
NYHA III/IV, *n* (%)	41 (31.1)
Comorbidities, *n* (%)	
HTN	103 (78)
DM	23 (17.4)
Smoking	16 (12.2)
Alcohol	20 (15.2)
Drugs (%)	
ACEI/ARBs	89 (67.4)
ALD antagonist	93 (70.5)
Warfarin	37 (28.0)
Statins	13 (9.8)
Beta-blockers	12 (9.1)
RVD TAPSE (mm)	
<15	26 (19.9)
<20	86 (65.2)

LVDD – Left ventricular internal dimension in diastole; PWTd – Posterior wall thickness in diastole; IVST – Interventricular septal thickness; EF – Ejection fraction; RVD – Right ventricular dimension; LAD – Left atrial dimension; NYHA – New York Heart Association; ACEI – Angiotensin-converting enzyme inhibitors; ARBs – Angiotensin receptor blockers; ALD – Aldosterone; TAPSE – Tricuspid annular plane systolic excursion; LVM – Left ventricular mass; DBP – Diastolic blood pressure; SBP – Systolic blood pressure; HTN – Hypertension; DM – Diabetes mellitus

Table 2: Clinical, demographic, and echocardiographic characteristics of those with right ventricular dimension compared to those without right ventricular dimension

Variables	TAPSE			*P*
	>20 (mm)	15-20 (mm)	<15 (mm)	
n	46	60	26	
Age (years)	55.5±13.7	62.2±16.3	70.6±11.9	0.029*
SBP (mmHg)	145.2±27.3	129.0±30.7	114.4±13.6	0.008*
DBP (mmHg)	88.2±20.0	82.8±19.0	71.9±16.2	0.103
Gender (males)	30	28	18	0.430
Comorbidities				
HTN (*n*)	38	50	15	0.025*
DM (*n*)	9	7	7	0.273
NYHA III/IV (*n*)	4	23	15	0.034*
Medications				
Beta blockers (*n*)	8	2	2	0.757
ACEI/ARBs (*n*)	29	24	25	0.012*
ALD antagonists (*n*)	28	42	23	0.469
LV EF (%)	56.1±7.5	46.4±10.8	34.6±5.9	<0.000*
IVST (mm)	12.5±2.5	13.6±2.5	11.3±1.2	0.065
PWTD (mm)	12.2±2.1	12.9±1.7	12.5±1.8	0.584
LVDD (mm)	45.8±11.5	49.3±11.7	53.9±12.7	0.336
RVD (mm)	27.1±2.6	27.9±3.9	38.0±3.9	<0.000*
LVM (g)	127.8±58.9	151.9±48.4	170.0±67.5	0.024*
LVME/MA rat	0.92±0.37	1.1±1.01	1.3±0.81	0.462
TE/TA ratio	0.85±0.25	1.01±0.54	1.84±1.1	0.002*
LAD (mm)	40.6±6.7	46.6±8.9	55.1±6.0	<0.000*
TAPSE (mm)	23.1±3.5	17.8±1.5	11.6±1.9	<0.000

*Statistically significant. LVDD – Left ventricular internal dimension in diastole; PWTD – Posterior wall thickness in diastole; IVST – Interventricular septal thickness; EF – Ejection fraction; RVD – Right ventricular dimension; LAD – Left atrial dimension; NYHA – New York Heart Association; ACEI – Angiotensin-converting enzyme inhibitors; ARBs – Angiotensin receptor blockers; ALD – Aldosterone; TAPSE – Tricuspid annular plane systolic excursion; HTN – hypertension; DM – Diabetes mellitus; LVM – Left ventricular mass; DBP – Diastolic blood pressure; SBP – Systolic blood pressure; LV – Left ventricular; LVME – Left ventricular mass estimation; MA – Late transmitral Doppler velocity; TE – Early transtricuspid Doppler velocity; TA – Late trans-tricuspid Doppler velocity

Table 2 shows the clinical and echocardiographic variables associated with RVD. RVD is associated with increasing age as those with RVD were more likely to be older than those without RVD. Furthermore, SBP and EF were much significantly lower when comparing those with moderate-severe RVD to those with mild RVD and those without RVD (114.4 ± 13.6 vs. 129.0 ± 30.7 vs. 145.27 ± 27.3 mmHg and 34.6 ± 5.9 vs. 46.6 ± 10.8 vs. 56.1 ± 7.5% $P < 0.05$, respectively). Those with RVD had an increased RV dimension compared to those without RVD (38.0 ± 3.9 vs. 27.9 ± 2.6 vs. 27.1 v2.6 mm, $P < 0.05$, respectively). Heart failure patients with RVD were less likely to be associated with hypertension and they had significantly increased LV mass and RV diastolic transtricuspid indices compared to those without RVD. There was no gender difference in the prevalence of RVD among these heart failure patients. LAD was significantly higher in relation to the degree of RVD compared to those without RVD as shown in Table 2.

Participants were grouped into HFREF or HFPEF. There was significantly higher proportion of participants with HFREF. There was no significant age difference between those with HFREF or those with HFPEF; neither were there differences in gender association, SBP, or DBP. However, mean TAPSE was significantly higher among those with HFPEF than among those with HFREF (21.2 ± 3.6 vs. 15.3 ± 4.0 mm, $P < 0.001$). Almost all heart failure patients with severe RVD had HFREF. There was also significant difference between transmitral E/A ratio and transtricuspid E/A ratio between the two groups. LAD and LV mass were significantly higher among patients with HFREF compared to those with HFPEF (53.6 ± 6.8 vs. 39.6 ± 5.0 and 180.7 ± 59.1 vs. 118.5 ± 38.3 g, $P < 0.05$, respectively) [Table 3].

Table 4 shows the correlation of TAPSE with clinical and echocardiographic parameters. Age, LAD, LV mass, and tricuspid E/A ratio were significantly but inversely

Table 3: Clinical and echocardiographic variables between subjects with heart failure with reduced ejection fraction compared to those with heart failure with preserved ejection fraction

Variables	HFREF	HFPEF	*P*
n (%)	80 (60.6)	52 (39.4)	
Age (years)	64.5±15.9	58.7±14.5	0.248
Gender, males	42	34	0.768
SBP (mmHg)	128.7±33.0	134.4±24.5	0.164
DBP (mmHg)	84.7±24.1	80.6±13.9	0.642
LVDD (mm)	53.5±13.2	45.0±9.3	0.023*
RVD (mm)	33.1±5.8	26.7±2.8	<0.000*
TAPSE<15 (mm)	1	25	<0.000*
TAPSE (mm)	15.3±4.0	21.2±3.6	<0.000*
Transmitral E/A ratio	1.5±1.0	0.76±0.22	0.001*
Tricuspid E/A ratio	1.4±0.9	0.83±0.23	0.003*
EF (%)	36.4±5.2	57.1±5.4	<0.000*
LAD (mm)	53.6±6.8	39.6±5.0	<0.000*
LVM (g)	180.7±59.1	118.5±38.3	<0.000*

*Statistically significant. LVDD – Left ventricular internal dimension in diastole; EF – Ejection fraction; RVD – Right ventricular dimension; LAD – Left atrial dimension; TAPSE – Tricuspid annular plane systolic excursion; HFREF – Heart failure with reduced ejection fraction; HFPEF – Heart failure with preserved ejection fraction; DBP – Diastolic blood pressure; SBP – Systolic blood pressure; LVM – Left ventricular mass

Table 4: Correlation of tricuspid annular plane systolic excursion with clinical and echocardiographic parameters

Variables	Correlations	*P*
Age (years)	−0.359	<0.000*
SBP (mmHg)	0.289	0.029*
DBP (mmHg)	0.186	0.167
PR (/min)	−0.026	0.842
LVDD (mm)	−0.203	0.129
EF (%)	0.615	<0.000*
ME (m/s)	−0.016	0.916
MA (m/s)	0.297	0.048*
TE (m/s)	−0.323	0.025*
TA (m/s)	0.358	0.015*
LAD (mm)	−0.522	<0.000*
LVM (g)	−0.276	0.042*
LVM E/A ratio	−0.178	0.242
Tricuspid E/A ratio	−0.450	0.002*

*Statistically significant. SBP – Systolic blood pressure; DBP – Diastolic blood pressure; LVDD – Left ventricular internal dimension in diastole; EF – Ejection fraction; LAD – Left atrial dimension; LVM – Left ventricular mass; ME – Early mitral Doppler velocity; MA – Late transmitral Doppler velocity; TE – Early transtricuspid Doppler velocity; TA – Late transtricuspid Doppler velocity; PR – Pulse rate

correlated to TAPSE. SBP and LV EF, mitral A velocity, and tricuspid A velocity were positively correlated with TAPSE.

DISCUSSION

Understanding RV function in heart failure is a big challenge in cardiovascular medicine. This is due to many reasons. Quantitative assessment of RV structure and function is difficult due to the position of the RV and also due to the fact that it is a lower pressure system. Several RV functional indices have been proposed to assess RV function with different sensitivity and specificity. Many of them have been correlated to other conventional indices of systolic and/or diastolic function.[18-20]

This study shows that RVD is common in Nigerians with heart failure almost two-third of heart failure patients have some degree of RVD. RVD is an important prognostic factor in patients with heart failure, and it is independent of LV EF and pulmonary hypertension.[18,19] Tricuspid annular plane systolic excursion (TAPSE) is a simple and reproducible index of RV function.[20] The findings of this study are similar to what other authors have documented from other part of the world.[21] Prevalence of RVD in heart failure patients ranged from 50% to 75% depending on the technique of measurement or comorbid factors.[21,22]

This study also showed that RVD is associated with many clinical and demographic correlates. RVD was associated with increasing age, reduced SBP and DBP, and more likely to be in New York Heart Association Stage III/IV compared to those without RVD. Nonhypertensive causes were also more likely to be the etiology of the heart failure among those with RVD compared to those without RVD. There was no gender bias as to the determinant of RVD. As per echocardiographic parameters, RVD was progressively associated indirectly with LV EF. Those with RVD were more likely to have reduced LV EF compared to those without RVD. RV dimension was also significantly higher among patients with RVD compared to those without RVD. These echocardiographic parameters reflect more advanced heart failure and therefore suggest that right heart failure with RVD are likely to have a worse prognosis. A similar pattern was noted with LAD, tricuspid E/A ratio, and LV mass. Most of these are conventional markers of prognosis in heart failure patients and thus correlate to the fact that TAPSE as in index of RVD in heart failure patients seems to identify a group of people with increased cardiovascular risk for mortality. This is in agreement with other studies that have correlated TAPSE with survival risk and shown that TAPSE is a good determinant of cardiovascular risk and mortality among those with HFPEF or HFREF.[13,15,18]

Another interesting finding from this study is the association of RVD with HFREF than HFPEF. HFPEF continues to become an important issue worldwide in cardiovascular medicine. In this study, HFREF seemed to be more associated with RVD compared to those with HFPEF. In a study by Adhyapak, the prevalence of RVD was shown to be significantly lower among HFPEF patients compared to HFREF patients.[23] One reason for this may be due to the fact that the RV may be involved by an ischemic or myopathic process in patients with HFREF as against HFPEF where the LV is often primarily affected. Indices of diastolic dysfunction expectedly were more likely to be abnormal among those with HFPEF compared to those

with HFREF. Whether in HFREF or HFPEF, TAPSE has been demonstrated to be a reliable clinical and follow-up prognostic marker in them.[24,25]

This study also revealed that an index of RV function, in this case, TAPSE was well correlated with many clinical and echocardiographic parameters. TAPSE was significantly well correlated with SBP, LV EF and inversely correlated with age, LV mass, LAD, and Doppler velocities of late transmitral flow and tricuspid flow. These associations agreed with what other authors have shown among heart failure patients.[26] Many of these are conventionally acceptable standardized way estimating right and left systolic and diastolic functions. Therefore, TAPSE can be conveniently useful to assess cardiovascular risk of heart failure patients and low TAPSE is associated with increased cardiovascular risk and mortality.

There are many potential causes of RVD in heart failure patients. Due to the varying etiology of HF in this cohort with most of them due to hypertension similar to what has been seen in previous studies,[27] RV is equally affected in hypertension.[28] Additional causes include additional insult of lung pathologies, chronic obstructive pulmonary disease, pulmonary embolism, and other right heart diseases condition which might actually be present to worsen the clinical scenario of these patients although we did not set out to look for these confounders in this study cohort.

Many studies have documented that cardiovascular mortality is associated with lower EF, left atrial dilatation, LV dilatation, increasing age, and other clinical and demographic parameters. This study therefore concludes that TAPSE as an index of RVD is associated with clinical and echocardiographic correlates of advanced heart failure and most likely poorer prognosis.

This study has some limitations. First, it is a hospital-based study, and the study cohort may not totally represent the population. Further, serial measurements of TAPSE would be more beneficial as additional pressure and volume changes occur with treatment in heart failure. The impact of other pathologies such as lung emphysema and pulmonary embolism and the presence of likely isolated right heart disease were not evaluated in this study. This could have impacted on RV function in heart failure.

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Conflicts of interest
There are no conflicts of interest.

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