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Research Article

Right Ventricular Function in Subjects with Heart Failure in a Cardiac Clinic in South West Nigeria

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Abstract

Aim: Right ventricular function is an important entity in heart failure. Patients with right ventricular dysfunction (RVD) have poorer prognosis and exercise tolerance than those with preserved right ventricular systolic function. Tricuspid annular plane systolic excursion (TAPSE) has been proposed as a simple and reproducible parameter for qualitative assessment of RV systolic function/ejection fraction. This study aims at describing right ventricular function/dysfunctions among heart failure subjects in a specialized cardiac facility in south–western Nigeria.

Methods: 132 subjects 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. Right ventricular function was assessed with TAPSE. Statistical analysis was done using SPSS 16.0. P<0.05 was taken as statistically significant.

Results: The mean age of study participants was 62.1 ± 14.2 years. Right ventricular systolic dysfunction (TAPSE<20 mm) was found in 86 (65.2%) of all subject while moderate-to-severe RV dysfunction (TAPSE<15 mm) was found in 26 (19.7%). Those with RVD are more likely to be older and had a larger left ventricular internal diastolic dimension than those without RVD. Systolic, diastolic blood pressure and ejection fraction were significantly lower among subjects with RVD than those with normal RV function.

Conclusion: Right ventricular dysfunction 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: Right heart; Right ventricular dysfunction; Heart failure; Prevalence; Clinical correlates

Introduction

The prevalence of heart failure continues to increase worldwide and account for a major part of health care expenditure in developed and developing economies [1,2]. The increasing burden of risk factors for heart failure seems to be the 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 function in heart failure patients [4]. Little attention is also placed on the methods of detecting right ventricular dysfunction 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 pumps blood to the lungs, 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 the right ventricle is equally affected in hypertension considering the diastolic parameters among Nigerians [7,8]. The right ventricle is exposed to similar pressure, volume 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 right ventricular function, most reports on heart failure are silent on the contribution of right heart dysfunction in subjects with heart failure [10]. It is worthy of note that an incompetent right ventricle will obviously leads to poor biventricular function even at the expense of increased left ventricular adaptations.

The measurement of right ventricular 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. Also, 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 right ventricular loading conditions [12]. Markers such as Tricuspid annular plane systolic or diastolic excursion (TAPSE), right ventricular ejection fraction, right ventricular index of myocardial performance (Tei index), right atrial size, right ventricular dilatation among others are useful in assessing for right ventricular dysfunction [13-15]. This study therefore aimed to determine the prevalence of right ventricular dysfunction using the Tricuspid annular pulmonary systolic excursion in subjects with heart failure and also their associated clinical correlates in a private cardiac clinic in south-west Nigeria.

Materials and Methods

This was a cross sectional study. All consecutive subjects 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 south west Nigeria. The diagnosis of heart failure was made using standardized Framingham's criteria [16]. They include all subjects with heart failure both with preserved and reduced ejection fraction 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 and echocardiography.

Information obtained from the clinical records include 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 and diastolic blood pressure and pulse rate were obtained. Electrocardiography was done using ECG 1200 by Contec Medical systems, China. Echocardiography was performed using the HP Sonos 2500 by HP Inc. USA with a 3.5MHz probe. All echocardiography were performed according to 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: left ventricular internal dimension in diastole (LVIDd), left ventricular internal dimension in systole (LVIDs), left ventricular posterior (PWTd) and septal wall dimension (IVSd) in diastole, ejection fraction (EF), fractional shortening (FS), left atrial dimension (LAD), right ventricular chamber dimension (RVD), aortic root dimension(AOD) and aortic cusp separation (ACS). Global and regional assessment for wall motion abnormalities were made visually and reported. The electrocardiography was interpreted by the author blinded to the clinical data of the subjects. Parameters such as heart rate, rhythm, QRS axis, PR interval and QTc were obtained. Left ventricular hypertrophy was defined using either 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.

Right ventricular dysfunction was defined by the Tricuspid annular pulmonary systolic excursion (TAPSE) as TAPSE<20 mm. Moderate-severe right ventricular dysfunction was defined as TAPSE<15 mm. Right atrial and right ventricular dimensions were also compared between the groups.

Data was analyzed using the Statistical Package for Social Sciences (SPSS) Chicago Ill version 16.0. Numerical data were summarized as mean ± standard deviation. Qualitative data were summarized as frequency and percentages. Student t-test, Analysis of variance and chi square test were used as appropriate to determine differences between groups. P<0.05 was taken as 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 systolic and diastolic blood pressures were 136.6 ± 28.6mmHg and 83.2 ± 17.6 mmHg respectively. The left ventricular internal diastolic dimension, left ventricular chamber wall dimensions and other related echocardiographic findings are as shown in Table 1. Mean TAPSE was 18.4 ± 4.8 mm. About a third of them (31.1%) were in New York Heart Association III/IV at diagnosis. Most of them have co-morbidities/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 right ventricular dysfunction defined as TAPSE 15-19 mm was documented in 60 (45.5%) while moderate-severe right ventricular dysfunction as defined by TAPSE<15mm was documented in 26 (19.9%) of study participants.

Variable	Value
Age (years)	62.1 ± 14.2
Males (n)	76 (57.6%)
Mean systolic blood pressure (mmHg)	136.6 ± 28.6
Mean diastolic blood pressure (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%)
Co-Morbidities Hypertension (N) Diabetes Mellitus(N) Smoking (N) Alcohol (N)	103 (78%) 23 (17.4%) 16 (12.2%) 20 (15.2%)
Drugs Acei/Arbs Ald Antagonist Warfarin Statins Beta Blockers	89 (67.4%) 93 (70.5%) 37 (28.0%) 13 (9.8%) 12 (9.1%)
Rvd Tapse<15	26 (19.9%)
RVD TAPSE<20mm	86 (65.2%)

Table 1: clinical, demographic and other characteristics of study participants and relationship with TAPSE * - statistically significant Key to table: LVDD-left ventricular internal dimension in diastole, PWTd-posterior wall thickness in diastole, IVSd-interventricular septal thickness, EF-Ejection fraction, RVD-right ventricular dimension, Left atrial dimension, NYHA-New York Heart Association, ACEI-Angiotensin converting enzyme inhibitors, ARB-Angiotensin receptor blockers, ALD-aldosterone, TAPSE-Tricuspid annular plane systolic excursion.

Table 2 showed the clinical and echocardiographic variables associated with right ventricular dysfunction. RVD is associated with increasing age as those with RVD were more likely to be older than those without RVD. Also systolic blood pressure and ejection fraction 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 right ventricular dimension compared to those without RVD (38.0 ± 3.9 vs. 27.9 ± 2.6 vs. 27.1v2.6 mm, p<0.05 respectively). Heart failure subjects with RVD were less likely to be associated with

hypertension and they had significantly increased left ventricular mass and right ventricular diastolic trans-tricuspid indices compared to those without RVD. There was no gender difference in the prevalence of RVD among these heart failure subjects. Left atrial dimension was significantly higher in relation to the degree of RVD compared to those without RVD as shown in Table 2.

Variables	TAPSE>20MM	TAPSE 15-20MM	TAPSE<15MM	P value
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) Dm (N) Nyha Iii/Iv (N)	38 9 4	50 7 23	15 7 15	0.025* 0.273 0.034*
Medications Beta Blockers (N) Acei/Arbs (N) Ald Antagonists(N)	8 29 28	2 24 42	2 25 23	0.757 0.012* 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

Table 2: clinical, demographic and echocardiographic characteristics of those with RVD compared to those without RVD Key to table: LVDD-left ventricular internal dimension in diastole, PWTd- posterior wall thickness in diastole, IVSd- interventricular septal thickness, EF-Ejection fraction, RVD-right ventricular dimension, Left atrial dimension, NYHA-New York Heart Association, ACEI- Angiotensin converting enzyme inhibitors, ARB-Angiotensin receptor blockers, ALD-aldosterone, TAPSE-Tricuspid annular plane systolic excursion, HTN-hypertension, DM-Diabetes mellitus, LVM- left ventricular mass. *-statistically significant

Participants were grouped into heart failure with reduced (HFREF) or with preserved ejection fraction (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, systolic or diastolic blood pressure. 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 subjects with severe RVD had heart failure with reduced ejection fraction. There was also significant difference between transmitral E/A ratio and transtricuspid E/A ratio between the two groups. Left atrial dimension and left ventricular mass were significantly higher among subjects 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).

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<15mm	1	25	0.000*
TAPSE (mm)	15.3 ± 4.0	21.2 ± 3.6	0.000*
Mitral 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*

Table 3: Clinical and echocardiographic variables between subjects with HFREF compared to those with HFPEF.*-statistically significant Key to table: LVDD-left ventricular internal dimension in diastole, EF-Ejection fraction, RVD-right ventricular dimension, Left atrial dimension, ACEI-Angiotensin converting enzyme inhibitors, ARB-Angiotensin receptor blockers, ALD-aldosterone, TAPSE-Tricuspid annular plane systolic excursion, HFREF-Heart failure with reduced ejection fraction, HFPEF-Heart failure with preserved ejection fraction.

Table 4 shows the correlation of TAPSE with clinical and echocardiographic parameters. Age, left atrial dimension, left ventricular mass and tricuspid E/A ratio were significantly, but inversely correlated to TAPSE. Systolic blood pressure and left ventricular ejection fraction, mitral A velocity and tricuspid A velocity were positively correlated with TAPSE.

Variables	Correlations	P Value
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
TRIC E/A Ratio	-0.450	0.002*

Table 4: Correlation of Tapse with Clinical and Echocardiographic Parameters *-statistically significant Key to table: SBP-systolic blood pressure, DBP-diastolic blood pressure, LVDD-left ventricular internal dimension in diastole, EF-Ejection fraction, RVD-right ventricular dimension, LAD-Left atrial dimension, TAPSE-Tricuspid annular plane systolic excursion, LVM- left ventricular mass, ME- early mitral Doppler velocity, MA-late transmittal Doppler velocity, TE- early trans tricuspid Doppler velocity, TA- late trans-tricuspid Doppler velocity.

Discussion

Understanding right ventricular function in heart failure is a big challenge in cardiovascular medicine. This is due to many reasons. Quantitative assessment of right ventricular structure and function is difficult due to the position of the right ventricle and also due to the fact that it is a lower pressure system. Several right ventricular functional indices have been proposed to assess right ventricular 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 subjects have some degree of right ventricular dysfunction. RVD is an important prognostic factor in subjects with heart failure and it is independent of left ventricular ejection fraction and pulmonary hypertension [18,19]. Tricuspid annular plane systolic excursion (TAPSE) is a simple and reproducible index of right ventricular 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 subjects ranged from 50-75% depending on the technique of measurement or co-morbid factors [21,22].

This study also showed that RVD is associated with many clinical and demographic correlates. RVD was associated with increasing age, reduced systolic and diastolic blood pressure and more likely to be in New York Heart Association stage III/IV compared to those without RVD. Non-hypertensive 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 left ventricular ejection fraction. Those with RVD were more likely to have reduced LV ejection fraction compared to those without RVD. Right ventricular dimension was also significantly higher among subjects with RVD compared to those without RVD. These echocardiographic parameters reflect a 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 left atrial dimension, tricuspid E/A ratio and left ventricular mass. Most of these are conventional markers of prognosis in heart failure subjects and thus correlates to the fact that TAPSE as in index of RVD in heart failure subjects 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 HF with preserved or reduced ejection fraction [13,15,18].

Another interesting finding from this study is the association of RVD with heart failure with reduced ejection fraction than heart failure with preserved ejection fraction. Heart failure with preserved ejection fraction continues to become an important issue worldwide in cardiovascular medicine. In this study, heart failure with reduced ejection fraction seemed to be more associated with RVD compared to those with heart failure with preserved ejection fraction. In a study by Adhyapak, the prevalence of RVD was shown to be significantly lower among HF subjects with preserved ejection fraction compared to those with reduced ejection fraction [23]. One reason for this may be due to

the fact that the right ventricle may be involved by an ischemic or myopathic process in patients with HFwREF as against HFwPEF where the left ventricle is often primarily affected. Indices of diastolic dysfunction expectedly were more likely to be abnormal among those with HFwPEF compared to those with HFwREF. Whether in HFwREF or HFwPEF, 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 right ventricular function, in this case, TAPSE was well correlated with many clinical and echocardiographic parameters. TAPSE was significantly well correlated with systolic blood pressure, left ventricular ejection fraction and inversely correlated with age, left ventricular mass, left atrial dimension and Doppler velocities of late transmitral flow and tricuspid flow. These associations agreed with what other authors have shown among heart failure subjects [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 subjects. 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] right ventricle is equally affected in hypertension [28]. Additional caucuses include additional insult of lung pathologies, COPD, pulmonary embolism and other right heart diseases condition which might actually be present to worsen the clinical scenario of these patients although we didn't set out to look for these confounders in this study cohort.

Many studies have documented that cardiovascular mortality is associated with lower ejection fraction, left atrial dilatation, left ventricular dilatation, increasing age and other clinical and demographic parameters. This study therefore conclude 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. Firstly, it is a hospital based study and the study cohort may not totally represent the population. Also, 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, pulmonary embolism and the presence of likely isolated right heart disease were not evaluated in this study. This could have impacted on right ventricular function in heart failure.

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