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Right Ventricular Function as a Predictor for Outcome in Heart Failure Patients according to Ejection Fraction

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Abstract

Right ventricle (RV) function has been an important independent predictor of morbidity and mortality in patients with congenital heart disease, heart failure (HF), pulmonary hypertension, and coronary artery disease. The objective of this study was the early prediction of RV dysfunction as a predictor for outcome in HF patients according to ejection fraction (EF). This prospective study involved 100 patients diagnosed with HF according to EF, both sexes. Patients were divided according to EF into three groups: Group A (n=31): HF with preserved left ventricular EF (HFpEF) with left ventricular EF (LVEF) >50%, Group B (n=40): HF with mildly reduced left ventricular EF (HFmrEF) with LVEF 40-50% and Group C (n=29): HF with reduced left ventricular EF (HFrEF) with LVEF <40%. The sensitivity and specificity for N-terminal prohormone of B-type natriuretic peptide (NT-pro BNP) as a predictor of poor outcome among HF patients were 100%, 91.4% respectively and with cutoff point more than 834 pg/ml. The sensitivity and specificity for RV fractional area change (RV FAC) as a predictor of poor outcome among HF patients were 83.6%, 82.8% respectively and with cutoff point less than 32%**.** The sensitivity and specificity for RV Global longitudinal strain (RVGLS) as a predictor of poor outcome among HF patients were 98.2%, 85.7% respectively and with cutoff point more than -15.2%**.** The sensitivity and specificity for tricuspid annular plane systolic excursion (TAPSE) as a predictor of poor outcome among HF patients were 98.2%, 85.7% respectively and with cutoff point less than 16 cm. RV dysfunction is an independent determinant of outcomes in patients with HF, and it demonstrates that RV free wall strain is a stronger and more precise predictor of outcome than RV global strain in the presence of LV systolic dysfunction.

Keywords: Right Ventricle, Outcome, Heart Failure, Ejection Fraction

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1. Introduction

Heart failure (HF) is a clinical syndrome with symptoms and or signs caused by a structural and/or functional cardiac abnormality and corroborated by elevated natriuretic peptide levels and or objective evidence of pulmonary or systemic congestion [1]. The American Heart Association and American College of Cardiology have defined four stages of HF to help people understand how the condition changes over time and the kinds of treatments that are used for each [2]. The right ventricle (RV) [3] has long been considered a dispensable cardiac chamber that does not contribute significantly to overall cardiac function. Yet studies published in the last several decades have revealed that RV function has been an important independent predictor of morbidity and mortality in patients with congenital heart disease, HF, pulmonary hypertension, and coronary artery disease, and the most recent investigations showed an undoubted correlation between RV hypertrophy and the risk of HF or death in a multi-ethnic population free of cardiovascular disease [4]. In clinical settings, 2-dimensional echocardiography (2DE) has been used for RV evaluation; however, cardiac magnetic resonance (CMR) has still been considered the gold standard for RV imaging. The introduction of new imaging techniques, especially echocardiographic tools such as tissue Doppler–derived strain, speckle tracking, and 3-dimensional echocardiography (3DE), could provide an accurate assessment of RV function, mechanics, and structure, comparable with CMR results [5].

Cardiac computed tomography (CT) provides precise and reproducible RV volume parameters compared with CMR, as well as comparing with 3DE, and can be considered a reliable alternative in the situation where 3DE is unavailable or the patient is not a suitable candidate for CMR [6]. The evaluation of RV diastolic function in clinical settings usually implies assessment of the RV inflow by pulsed wave Doppler and evaluation of inferior vena cava and hepatic veins. In the current guidelines, emphasized that the presence of RV diastolic dysfunction was associated with worse functional class and was an independent predictor of mortality in patients with chronic HF and pulmonary hypertension [7]. During acute RV pressure overload, RV diastolic function is not affected, whereas chronic RV

pressure overload impacts RV diastolic dysfunction, resulting in prolonged diastolic relaxation time and increased RV diastolic stiffness. However, the latest study showed that during acute pressure overload, restoring forces initially decreased, but recovered at advanced stages. This biphasic response is associated with alterations of septal curvature provoked by variations in the diastolic LV-RV pressure balance [8]. The aim of this work was the early prediction of RV dysfunction as a predictor for outcome in HF patients according to ejection fraction (EF).

2. Methods

This prospective study involved 100 patients diagnosed with HF according to [Symptoms with or without signs of HF, elevated natriuretic peptides (NT-proBNP ≥125 pg/mL) and relevant structural heart disease: (LV hypertrophy (LV mass index ≥115 g/m2 in males and ≥95 g/m2 in females), left atrial enlargement (>34 mL/m2) or diastolic dysfunction (E/e´ ≥13 and a mean e´ septal and lateral wall <9 cm/s))], both sexes. The research conducted from June 2022 to June 2023, following approval by Zagazig University Institutional Review board (ZU-IRB#6776-24-2-2021) confirmed that all methods performed in accordance with relevant guidelines and informed written consent obtained from all patients. Exclusion criteria were subjects who have any medical condition that affects RV as (Hypertension, diabetes mellitus, and congenital heart disease, and rheumatic heart disease, valvular heart disease, the hypertrophic cardiomyopathy, congestive HF, kidney and liver disease). Subjects on drugs known to affect RV function as (Amphetamine derivatives, cathinone and phenylephrine).

Patients divided according to EF into three groups: Group A (n=31): HF with preserved left ventricular EF (HFpEF) with left ventricular EF (LVEF) >50%, Group B (n=40): HF with mildly reduced left ventricular EF (HFmrEF) with LVEF 40-50% and Group C (n=29): HF with reduced left ventricular EF (HFrEF) with LVEF <40%. A thorough medical history including (age, sex, and risk factors for coronary artery disease (CAD) as hypertension, diabetes mellitus, and smoking, dyslipidemia, family history of premature coronary artery disease CAD), general, local examination and laboratory investigations (Complete blood count (CBC), hemoglobin (g/dl), TLC (x103/L), PLT (x103/L), kidney function test (serum creatinine and urea) and NT-proBNP). Blood samples of patients obtained in morning between 8:00am and 10:00am after a fasting period of at least 8 hours. Blood samples of all patients obtained for complete blood count, CBC, random blood glucose sugar, kidney function test (serum creatinine and urea), NT-proBNP studied. Hypertension defined as values ≥140 mmHg SBP and/or ≥90 mmHg DBP according to ESH/ESC Guidelines for management of arterial hypertension (2018) [9] .

Diabetes mellitus was diagnosed on basis listed by American Diabetes Association (2010) as: Fasting blood sugar ≥ 126 mg/dl or 2 hours postprandial blood sugar ≥ 200mg/dl or HBA1C ≥ 6.5 or Symptoms of diabetes plus casual plasma glucose concentration ≥ 200 mg/dl. Casual is defined as any time of day without regard to time since last meal. The classic symptoms of diabetes include polyuria, polydipsia, and unexplained weight loss [10]. Smoking was defined as active smoking in the last 6 months [11]. dyslipidaemia was considered according to recommendations of Third Report of the National Cholesterol Education Program (NCEP), when any of following was present: serum cholesterol ≥ 200 mg/dl, LDL ≥ 100 mg/dl, HDL < 40mg/dl for high-risk patients [12]. Family history of premature CAD, defined by presence of at least a first degree relative with a cardiovascular event or premature SCD at a young age (< 65 years for women and < 55 years for men) [13].

2.1. General and local examination

2.1.1. Blood pressure

According to the JNC-8 recommendations, in the office, blood pressure was measured at least twice after 5 minutes of rest, with the patient seated in a chair, the back supported, and the arm bare at heart level. A large adult-size cuff was used to measure blood pressure in overweight adults, in whom use of a standard-size cuff can spuriously elevate readings. Tobacco and caffeine were avoided for at least 30 minutes. Blood pressure was measured in both arms and after 5 minutes of standing, the latter to exclude a significant postural fall in blood pressure, particularly in older persons and in those with diabetes or other conditions that predispose to autonomic insufficiency. Resting blood pressure was measured using a standard mercury sphygmomanometer on the right arm in a sitting position following a minimum of five minutes rest. Phases I and V Korotkoff sounds were used to determine systolic and diastolic BP measurements. The mean of the last two measurements was used in the analysis.

2.1.2. Body mass index (BMI)

BMI, defined as the body weight divided by the square of the body height in meters, and is universally expressed in units of kg/m2, resulting from mass in kilograms and height in meters [14].

2.1.3. BMI classification

Less than 18.5 was underweight, 18.5–24.9 was healthy weight range, and 25–29.9 was overweight, 30 and over were obese.

2.1.4. Abdominal and chest examination

Cardiac examination: including inspection, palpation, and auscultation.

2.1.5. Twelve-lead surface Electrocardiography

All subjects had a resting simultaneous 12-lead electrocardiogram (ECG). At a paper speed of 25 mm/s with the machine control set at standard response, a standard lead II rhythm strip of 13–16 complexes and a minimum of three cardiac cycles per lead were recorded.

2.2. RVH criteria on ECG

2.2.1. General ECG features include

Right axis deviation (> 90 degrees), tall R-waves in RV leads; deep S-waves in LV leads, slight increase in QRS duration, ST-T changes directed opposite to QRS direction (i.e., wide QRS/T angle), may see incomplete RBBB pattern or qR pattern in V1 and evidence of right atrial enlargement.

2.2.2. Specific ECG features (assumes normal calibration of 1 mV = 10 mm)

Any one or more of following (if QRS duration < 0.12 sec): Right axis deviation (> 90 degrees) in presence of disease capable of causing RVH. R in aVR ≥ 5 mm. R in aVR > Q in aVR.

Any one of the following in lead V1:
R/S ratio > 1 and negative T wave. qR pattern. R gt; 6 mm, or S < 2mm, or rSR' with R' > 10 mm.
Other chest lead criteria:
R in V1 + S in V5 (or V6) 10 mm. R/S ratio in V5 or V6 < 1. R in V5 or V6 < 5 mm. S in V5 or V6 > 7 mm.
ST segment depression and T wave inversion in right precordial leads is usually seen in severe RVH such as in pulmonary stenosis and pulmonary hypertension [15] .

2.2.3. Conventional Trans-thoracic Echo-Doppler study

Trans-thoracic echocardiographic examination was done to all patients using HP SONOS (USA) and GE Vivid E9 (Norway) set with a 2.5 MHz transducer and SPECKLE TRACKING echocardiography was done by (Phillips, EPIC 7C; USA) with "S5-1" matrix array transducers equipped with STE technology and using a multi-frequency (1-5 MHz) for all cases. Images were taken while the patient in supine or in the left lateral position.

2.2.4. Right ventricular size

Compare the RV and the left ventricle. This can also be done by visual assessment. The left ventricle is usually at least thirty percent larger than the right one. In severe forms of RV dilatation, the apex of the heart is formed by the RV instead of the left one. The size of the RV can be determined either with 2-D measurements, area or volume calculations. M-Mode measurements were used at the beginning of echocardiography (parasternal axis). However, as these measurements are very inexact and strongly depend on how the Mode "cuts" through the RV, they are no longer used. It is far better to measure distances in 2-D. This is best done on an optimized 4-chamber view or a subcostal view at end-diastole. Roughly, the ventricle appears triangular on these views. Thus, the diameter varies, depending on the level at which the measurements are performed. Where to measure the dimensions of the RV in a four-chamber view two sites are commonly used: the basal distance (at the tricuspid annulus) and the mid-right-ventricular measurement (in the middle segment of the RV). Roughly, a mid-right-ventricular diameter of 35 to 40 mm or 42 to 45 mm at the base indicates right ventricular dilatation. Respiration influences the size of the RV. During inspiration it is slightly larger. It is important to take the patient's body surface area into account. An apical transducer position that is too high lead to overestimation of RV size. It is also possible to measure the width of the RVOT on a parasternal short axis view at the base. Here the upper limit of normal is 33 mm for the proximal aspect and 27 mm for the distal aspect at the level of the pulmonary valve.

2.2.5. NYHA classification

New York Heart Association (NYHA) functional class helps to classify congestive HF patients based on their symptoms. Class I: No symptoms of HF. Class II: Symptoms of HF with moderate exertion, such asambulating two blocks or two flights of stairs. Class III: Symptoms of HF with minimal exertion, such asambulating one block or one flight of stairs, but no symptoms at rest. Class IV: Symptoms of HF at rest.

2.2.6. Statistical analysis

All statistical analysis were performed using SPSS version 26 and Medcalc software as follow: Continuous data were represented as mean and standard deviation. Categorical data were represented as event and percentage. One way ANOVA was used for comparing the means of more than two groups. Chi-square test was used for comparing between categorical variables. Pearson correlation was used for assessing association between two continuous variables. Phi correlation was used for assessing association between two categorical variables. Point biserial correlation was used for assessing association between dichotomous and continuous variables. Binary logistic regression adjusted for baseline characters (glycemic status, age, and sex) were used. Areas under ROC curves and their standard errors were determined using the method of Cantor, and compared using the normal distribution, with correction for correlation of observations derived from the same cases. Value of area under a ROC curve [16] indicates: 0.90 – 1 = excellent, 0.80-0.90 = good, 0.70-0.80 = fair; 0.60-0.70 = poor; and 0.50-0.6 = fail. The optimal cutoff point was established at the point of maximum accuracy. Significant when the probability of error is less than 5% ($p < 0.05$). Non-significant when the probability of error is more than 5% ($p > 0.05$). Highly significant when the probability of error is less than 0.1% ($p<0.001$).

3. Results and discussion

3.1. Results

There was no significant difference as regard age, sex and BMI between studied groups Table 1. There was no significant difference as regard HR, DBP, hemoglobin, TLC, PLT, RBS, creatinine and urea between studied groups. There was a significant difference as regard SBP between studied groups (p=0.059). There was an increase in SBP in group C compared to other groups (119.48 ± 7.83). There was a highly significant difference as regard NT-pro BNP between studied groups (p=0.004). There was an increase in NT-pro BNP in group C compared to other groups (960.14 ± 243.74) Table 2. There was a very highly significant difference as regard LVEF, RV FAC, TAPSE, RVFWLS, RVGLS, NYHA and MACE between the studied groups (p<0.001, <0.001, <0.001, <0.001, <0.001, =0.003, =0.004, respectively). There was a decrease in LVEF, RV FAC, TAPSE, RVFWLS and RVGLS in group C compared to other groups [(38.62 ± 1.55), (30.59 ± 2.34), (15.21 ± 1.98), (-13.33 ± 7.13) and (-13.92 ± 1.75), respectively]. That NYHA class IV and MACE was more frequent in group C compared to other groups (24.1% and 48.3%, respectively). There was a significant difference as regard ePASP b/w studied groups (p=0.009).

There was an increase in ePASP in group C compared to other groups (31.34 ± 3.5). There was no significant difference regarding RVD mid cavity, RVD basal, Base-apex and mortality between the studied groups. Table 3. The sensitivity and specificity for NT-proBNP as a predictor of poor outcome among HF patients were 100%, 91.4% respectively and with cutoff point more than 834 pg/ml. The sensitivity and specificity for RV FAC as a predictor of poor outcome among HF patients were 83.6%, 82.8% respectively and with cutoff point less than 32%. The sensitivity and specificity for RVGLS as a predictor of poor outcome among HF patients were 98.2%, 85.7% respectively and with cutoff point more than -15.2%. The sensitivity and specificity for TAPSE as a predictor of poor outcome among HF patients were 98.2%, 85.7% respectively and with cutoff point less than 16 cm. Figure 1. We have done logistic regression analysis of factors predicting poor outcomes among HF

patients. Which include "age, male gender, BMI, SBP, DBP, TLC, RBS, Creatinine, NYHA III & IV, NT-pro BNP, LVEF, RV FAC, TAPSE, RVFWLS, and RVGLS".

We found that only significant predictors of poor outcomes among HF patients as follow by its order: 1stwas NT-pro BNP with 95% CI for exponent (B) range from 1.002 – 1.007, odd ratio equals to 1.005 (p = 0.001). The cutoff point of NT-pro BNP was >834 pg/ml calculated using Receiver Operating Curve characteristics (ROC). 2nd was RV FAC with 95% CI for exponent (B) range from 0.609 – 0.894, odd ratio equals to 0.738 (p = 0.002). The cutoff point of RV FAC ≤32 calculated using Receiver Operating Curve characteristics (ROC). 3rd was serum RV GLS with 95% CI for exponent (B) range from 1.349 – 6.320, odd ratio equals to 1.072 (p = 0.001). Cutoff point of RV GLS was > -15.2 calculated using Receiver Operating Curve characteristics (ROC). 4thwas serum TAPSE with 95% CI for exponent (B) range from 1.287 – 2.163, odd ratio equals to 1.775 (p = 0.009). Cutoff point of RV GLS was ≤ 16 calculated using Receiver Operating Curve characteristics (ROC) Table 4.

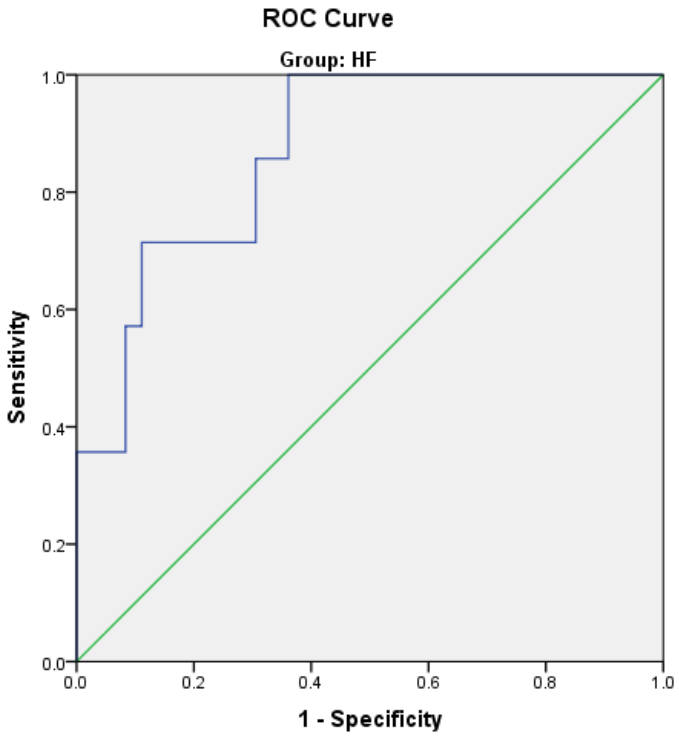
3.2. Discussion

Only a few studies have evaluated RV systolic function in the three categories of HF with regard for the importance of understanding changes in RV function and their effects on clinical presentation and outcomes; it is essential to define the prevalence and severity of RV dysfunction among the three groups and the degree of correlation between RV and LV systolic functions [17]. RV function has not been well studied in HFrEF; while it was recently studied in HFpEF, with the development of the new classification of HF (into preserved, mid-range, and reduced), definition and orientation of the mid-range group is unclear. There was a significant increase in SBP in group C compared to other groups, while there was no significant difference among groups regarding HR and DBP. This came in the line with Grand et al. [18] who reported that SBP was not associated with mortality in LVEF≥40% but was strongly associated with mortality in patients with LVEF<40%. Also, this supported by Darahim, and Eldeeb et al. [19-20] who found that there was insignificant different in DBP and HR between patients with event and those who without. In our study, there was no significant difference regarding RVD basal, RVD mid cavity and Base-apex between the studied groups. There was a decrease in LVEF, RV FAC and TAPSE in group C compared to other groups. There was an increase in ePASP, RVFWLS and RVGLS in group C compared to other groups. A study done by Eldeeb et al. [19] who showed that RVFAC was significantly high in normal RV function group than in impaired RV function group.

However, LVEF was not significant difference between both groups. This agreed with Carluccio et al. [16] who showed that compared with event-free patients, those who experienced events showed significantly lower LVEF and lower LVGLS, and increased sPAP. Both RVFWS and RVGLS were significantly impaired in patients with events, as was TAPSE. Also, Carluccio et al. [21]**.** This due to increasedePASP, Echo-HFscore, and impaired RVFWS and RV FACin patients with events. In contrast, TAPSE was not significant between events and no events group. This difference may be due to enrolled only patients with TAPSE >16 mm by protocol, this parameter did not differ between patients with and without events. Furthermore, Darahim [19] found that pulmonary artery systolic pressure was significantly high in event group. Present study revealed that NYHA class IV and MACE were more frequent in group C compared to other groups (24.1%). This came in the line with Carluccio et al., Carluccio et al. and Darahim [16-19-21] who showed patients with events had more advanced NYHA class than event-free patients. According to ROC curve analysis were found that RV FAC yielded significant at cut off point of 32 with sensitivity of 83.6% and specificity of 82.8%. RV GLS yielded significant at cut off point of -15.2 with sensitivity of 98.2% and specificity of 85.7%.

TAPSE yielded significant at cut off point of 16 with sensitivity of 83.3% and specificity of 71.4%. In logistic regression analysis, only significant predictors of poor outcomes among HF patients were NT-pro BNP with cutoff >834 pg/ml, RV FAC with cutoff ≤32, serum RV GLS with > -15.2 and serum TAPSE with cutoff≤ 16. This agreed with Berrill et al. [22] who reported that TAPSE (cutoff 1.7 cm), RV FAC (cutoff 35%), and LVEF (cutoffs for HF with preserved EF (LVEF > 50%). In the same line, Carluccio et al. [16] reported that RVFWS was an independent predictor of outcome. The best cutoff value of RVFWS for prediction of outcome was −15.3%. TAPSE was also a significant predictor of events. This supported by Carluccio et al. [16] who made measurement of longitudinal strain of RVFWS is able to predict outcome during follow-up, independently of, and incrementally to, TAPSE and other recognized clinical and echocardiographic predictors of events. A previous study done by [23] found that, although RVGLS and RVFWS measures had prognostic value, RVGLS better predicted episodes of HF. Our findings are consistent with those of Nagy et al. [24] showed that impaired RVGLS associated with mortality, while RVFWS showed only a tendency for mortality prediction. Moreover, Motoki et al. [25] found that RV global strain independently associated with cardiac events during follow-up. Supporting our findings, Darahim [19] found that RVFAC and TAPSE were significant predictor of primary events with cutoff 30% and 15.5 mm.

A study done by (Sade et al. [26] reported that 2D longitudinal strain of RVFWS emerged as a significant predictor of cardiac events independently of ischemic pathogenesis. Also, [27] showed that RVFWS had highest accuracy when diagnosing depressed RV stroke work index than RVGLS. RVFWS was strongest correlation of RV EF by cardiac magnetic resonance and strongest predictor of prognosis in such patients. Approving current study, Bay et al. [28] found that NT-pro BNP alone was a predictor of reduced LVEF at cut off value 357 pmol/l with sensitivity of 73%, specificity of 82%, positive predictive value of 24%, and a negative predictive value of 98%. RV function by strain analysis is a direct measurement of intrinsic RV myocardial deformation along longitudinal plane, which less affected by loading conditions & geometric assumptions than traditional parameters. Furthermore, STE has demonstrated high feasibility and reproducibility, strong prognostic role in different clinical settings, and capability to reclassify prognosis in presence of preserved values of other traditional parameters [23-29]. RV longitudinal strain still lacks clear standardization and validation, with consequent limitations in its implementation in clinical routine. Some studies measured RV deformation in terms of RVGLS, combines measurements from both RV free wall and inter ventricular septum, [5] while others limited analysis to RV free wall [21].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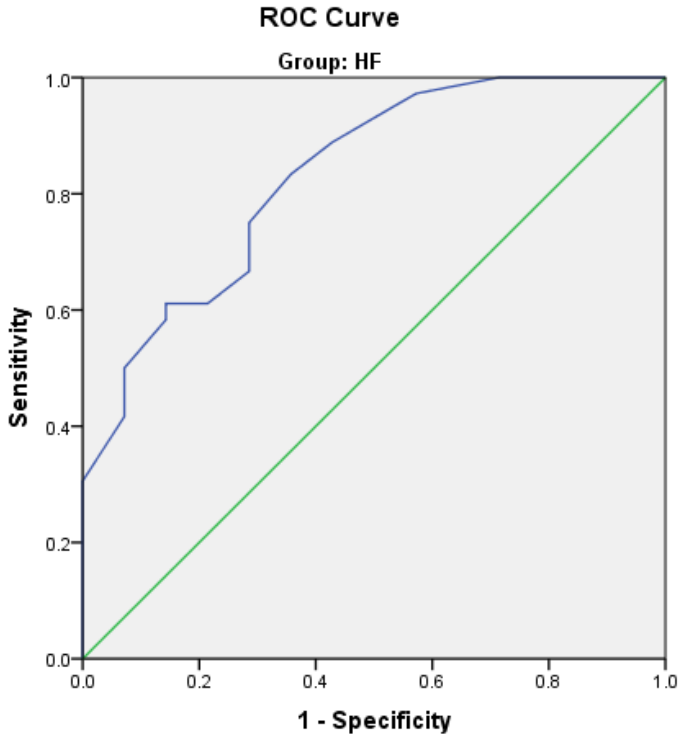
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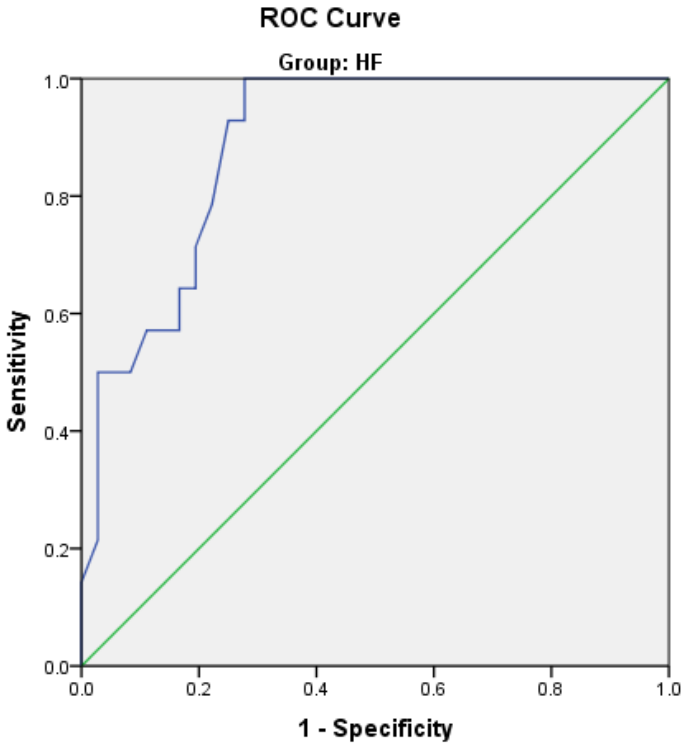

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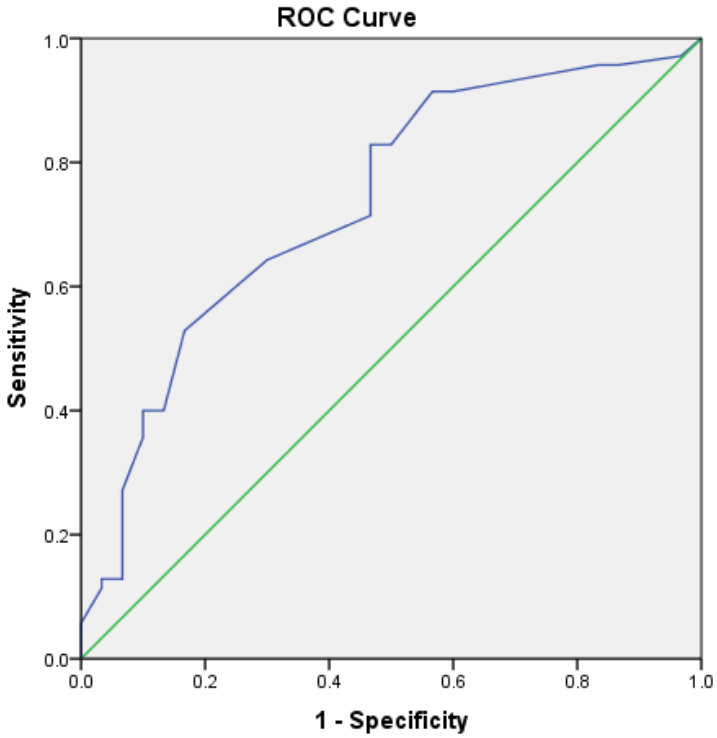

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Figure 1: ROC curve of A) NT-proBNP, B) RV FAC, C) RV GLS and D) TAPSE as a predictor of poor outcome among HF patients

Table 1: Demographic data between the studied groups

Variables		Group A (n=31)	Group B (n=40)	Group C (n=29)	F / χ^2	p
Age (years)		52.68 ± 10.44	57.95 ± 13.45	54.45 ± 10.27	1.88	0.158
Sex	Male	16 (51.6%)	22 (55%)	8 (27.6%)	5.66	0.059
	Female	15 (48.4%)	18 (45%)	21 (72.4%)		
BMI (kg/m^2)		28.1 ± 2.55	27.23 ± 3.41	27.95 ± 3.73	0.721	0.489

Data are presented as Mean ± SD. BMI: Body mass index; F: ANOVA test; χ2: Chi square test.

Table 2: Vital signs and laboratory parameters between the studied groups

Variables	Group A (n=31)	Group B (n=40)	Group C (n=29)	F	p
HR (beat/min)	91.42 ± 12.41	90.35 ± 12.03	88.1 ± 11.53	0.609	0.546
SBP (mmHg)	119.35 ± 8.92	115.25 ± 7.68	119.48 ± 7.83	3.16	0.047
DBP (mmHg)	75.16 ± 4.91	75.38 ± 4.99	74.31 ± 4.58	0.430	0.652
Laboratory parameters					
Hemoglobin(g/dl)	12.43 ± 1.2	12.57 ± 1.21	12.52 ± 1.18	0.123	0.885
TLC(x103/L)	7.92 ± 1.81	8.48 ± 2.75	8.2 ± 2.58	0.471	0.626
PLT (x103/L)	214.77 ± 25.27	211.23 ± 24.55	201.83 ± 23.25	0.250	0.779
RBS (mg/dl)	129.23 ± 16.99	133.1 ± 19.1	129.97 ± 13.88	0.517	0.598
Creatinine (mg/dl)	0.855 ± 0.148	0.899 ± 0.191	0.922 ± 0.125	1.33	0.269
Urea(mg/dl)	26.34 ± 5.59	24.85 ± 5.37	26.87 ± 6.53	1.17	0.315
NT-proBNP(pg/ml)	652.23 ± 296.26	839.78 ± 321.26	960.14 ± 243.74	KW 10.81	0.004

Data are presented as Mean ± SD. F: ANOVA test; HR: Heart rate; SBP: Systolic blood Pressure; DBP: Diastolic blood pressure

Table 3: Echo data, NYHA classification and outcome between the studied groups

Variables	Group A (n=31)	Group B (n=40)	Group C (n=29)	F	p
Echo data					
LVEF (%)	53.58 ± 2.1	46.1 ± 2.92	38.62 ± 1.55	**309**	**<0.001**
ePASP (mmHg)	28.55 ± 2.69	30.13 ± 3.89	31.34 ± 3.5	**4.99**	**0.009**
RVD mid cavity (cm)	2.75 ± 0.468	2.69 ± 0.425	2.82 ± 0.502	0.675	0.512
RVD basal (cm)	3.23 ± 0.503	3.17 ± 0.530	3.32 ± 0.608	0.683	0.507
Base-apex (cm)	6.63 ± 0.832	6.41 ± 0.866	6.38 ± 0.793	0.814	0.446
RV FAC (%)	35.19 ± 2.2	32.2 ± 2.31	30.59 ± 2.34	**32**	**<0.001**
TAPSE (cm)	20.27 ± 2.31	17.95 ± 3.1	15.21 ± 1.98	**29**	**<0.001**
RVFWLS (%)	-18.32 ± 1.17	-15.68 ± 2.86	-13.33 ± 7.13	**10**	**<0.001**
RVGLS (%)	-19.99 ± 2.27	-16.39 ± 1.96	-13.92 ± 1.75	**70**	**<0.001**
NYHA classification					
II	9 (29%)	24 (60%)	12 (41.4%)	16	0.003
III	21 (67.7%)	12 (30%)	10 (34.5%)		
IV	1 (3.2%)	4 (10%)	7 (24.1%)		
MACE	3 (9.7%)	13 (32.5%)	14 (48.3%)	11	0.004
Mortality	1 (3.2%)	4 (10%)	5 (17.2%)	3.27	0.195

Data are presented as Mean ± SD and number (%). F: ANOVA test; LVEF: Left ventricular ejection fraction. ePASP: Estimated Pulmonary Artery Systolic Pressure. RVD: right ventricular dimension. RV FAC: right ventricular Fractional Area Change. TAPSE: Tricuspid annular plane systolic excursion. RVFWLS: RV free wall longitudinal strain. RVGLS: RV global longitudinal strain.

Table 4: Multivariate regression analysis to determine the possible predictors of poor outcomes among HF patients

	OR	S.E.	p	95% Confidence Interval
Age	0.004	0.004	0.278	-0.004 – 0.012
Male gender	1.49	0.697	0.567	0.380 – 5.848
BMI	-0.003	0.016	0.857	-0.035 – 0.030
SBP	0.011	0.006	0.066	-0.001 – 0.024
DBP	-0.005	0.011	0.654	-0.028 – 0.018
TLC	0.016	0.017	0.345	-0.018 – 0.050
RBS	0.003	0.003	0.323	-0.003 – 0.008
Creatinine	-0.674	0.383	0.087	-1.451 – 0.102
NYHA III & IV	0.295	0.719	0.089	.072 – 1.207
NT-proBNP	1.005	0.001	**0.001**	1.002 – 1.007
LVEF	0.832	0.066	**0.006**	0.731 – 0.946
RV FAC	0.738	0.098	**0.002**	0.609 – 0.894
TAPSE	1.775	0.069	**0.009**	1.287 – 2.163
RVFWLS	4.228	0.497	**0.001**	1.595 – 11.208
RVGLS	1.072	0.394	**0.001**	1.349 – 6.320

OR: odd ratio; BMI: body mass index; SBP: Systolic blood Pressure; DBP: Diastolic blood pressure;TLC: total leucocyte count. PLT: Platelets. RBS: random blood sugar; NT-proBNP: N-terminal prohormone of brain natriuretic peptide. LVEF: Left ventricular ejection fraction. RV FAC: right ventricular Fractional Area Change. TAPSE: Tricuspid annular plane systolic excursion. RVFWLS: RV free wall longitudinal strain. RVGLS: RV global longitudinal strain.

Because of ventricular interdependence, a significant fraction of developed pressure and RV volume outflow actually depends on LV function. Indeed, although myoarchitecture of inter ventricular septum reflects wall of both the RV and LV, the major contribution to septum comes from middle "layer" of LV. This makes inter ventricular septum mainly a constituent part of LV. Since contractile function of septum is likely to be impaired in patients with HFrEF, contributing to the degree of LV dysfunction, this could potentially affect global RV strain measurement and prognostic value [21]. Limitations of our study were single center study, small sample size and lack of a control group.

4. Conclusions

RV dysfunction is an independent determinant of outcomes in patients with HF, and it demonstrates that RV free wall strain is a stronger and more precise predictor of outcome than RV global strain in the presence of LV systolic dysfunction.

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