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Journal of American Science

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Multidisciplinary Academic Journal Publisher

The Association between Right Ventricular Free Wall Strain and Exercise Capacity in Healthy Individuals Compared To Heart Failure Reduced Ejection Fraction Patients

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Abstract: Aim of study: To assess functional capacity in HFrEF patients as well as healthy individuals using RV free wall strain. Methods: This prospective cohort study was conducted on fifty patients scheduled for routine echocardiographic examination. All patients were evaluated by history taking and clinical examination, exercise ECG test, laboratory investigations and echocardiographic examination including RV assessment with speckle tracking. Patients were divided into two equal groups; one for healthy individuals and another for heart failure patients. Results: Patients in group A (healthy individuals) were younger than group B. There is significant difference in clinical parameters on initial assessment as the resting and maximal exercise heart rate, blood pressure were lower in group A. while exercise time and METs achieved were higher in the same group. Conventional echocardiographic measurements of RV were lower in group A, while FAC and TAPSE were significantly higher in the same group. RV and LV global longitudinal strain were significantly increased in group A (-21.12 ±3.45 vs. -14.53 ±1.93, p value <0.001) and (-27.86 ±1.13 vs. -19.86 ±4.34, p value <0.001) respectively. By correlation of RVGLS to other parameters, we found significant positive correlation with age, RV diastolic and systolic areas, RV-MPI, tricuspid E/A ratio, and LVGLS. Finally, we found significant negative correlation with METs, Exercise time, TAPSE, FAC. Conclusion: RV strain is independently associated with functional capacity in compensated heart failure patients as well as healthy individuals. RV function should be regarded as an important factor for exercise capacity.

[Mohamed Magdy Abdelrazik Edries, Mohamed Osama Fathy Ayed, Aly Aly Ramzy. **The Association between Right Ventricular Free Wall Strain and Exercise Capacity in Healthy Individuals Compared To Heart Failure Reduced Ejection Fraction Patients.** *J Am Sci* 2020;16(1):89-94]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 10. doi:10.7537/marsjas160120.10.

Key words: Functional capacity, Right ventricular function, heart failure with reduced ejection fraction

1. Introduction

Exercise capacity, as reflecting cardiac function, has been known as a powerful predictor of mortality among patients with various diseases [1]. Although the association between exercise capacity and traditional echocardiographic parameters remains indeterminate, emerging imaging modalities can help distinguish patients with preserved or impaired exercise capacity [2-4].

Among these modalities, speckle tracking echocardiography (STE) has been used to detect occult myocardial dysfunction that may result in reduced exercise capacity**[5]**. However, given that most of the previous studies focused on heart failure**[2]**, congenital heart disease**[6]**, chronic obstructive lung disease or athletes**[7]** the value of STE in detecting exercise capacity impairment in apparently healthy subjects remains unknown.

Therefore, investigating an imaging tool to evaluate the cardiac function as well as exercise capacity is helpful. Herein, we aim to identify the role of STE in detecting subtle myocardial dysfunction and its associated changes of exercise capacity in healthy individuals compared to asymptomatic heart failure patients.

2. Material and Methods

This is a single center, cross-sectional, comparative study that was conducted at cardiology department of Al-azhar University Hospital from February 2019 to November 2019.

It was included patients referred to cardiology department of Al-azhar University Hospital for echocardiographic assessment. All patients signed informed consents and this study was approved by ethical committee of Al-azhar University Hospital. Patients with severe valvular heart disease, those with contraindication to exercise ECG, AF patients, and acute decompensated HF (NYHA class III or IV) were excluded from this study.

Methods:

The patients will be divided into 2 groups; first one (Group A) includes healthy individuals (undergoing health check-ups) hypertension, diabetes, symptomatic heart failure, atrial fibrillation, significant valvular heart disease (above moderate severity), left ventricular ejection fraction less than 45%, and coronary artery disease, determined by the positive treadmill results will be excluded from this group. Clinical information on co-morbidities, medical history, and current cardiovascular medication was obtained by a careful review of each patient's medical record.

The second group (Group B) will include HFrEF patients with preserved RV function.

Exercise capacity was determined by a symptom limited treadmill exercise test using Modified Bruce protocol. The procedure was ceased according to the endurance of each individual and it could be a hallmark of exercise capacity and a representation of subclinical diseases. As has been reported, preserved exercise capacity was defined as an energy expenditure of more than 8 metabolic equivalent of task (MET).

all subjects received both standard and speckling tracking echocardiography. The chamber dimensions and left ventricular mass index (LVMI) were measured using the two-dimensionally guided M-mode method.

The right ventricle fractional area change (RVFAC) was measured with the apical 4-chamber view while LV ejection fraction (LVEF) was measured by both 2- and 4- chamber Simpson method. Biventricular diastolic function associated parameters (including isovolumic relaxation time (IVRT), isovolumic contraction time (IVCT), deceleration time (DT), trans-mitral early filling velocity (E) to atrial velocity (A) ratio and mitral E to early diastolic mitral annular velocity (e') ratio) were also measured. Peak systolic pulse Doppler tissue imaging was performed at the tricuspid annulus (S'). RV dimensions were defined right ventricular (RV) mid cavity dimension in the apical four chamber view, the basal (RVD1) and mid cavity (RVD2) RV minor dimensions, the RV longitudinal dimension (RVD3) and tricuspid annular plane systolic excursion (TAPSE) were also measured.

In addition, pulmonary artery systolic pressure (PAP) was obtained by the summation of the estimated trans-tricuspid valve pressure and the estimated right atrial pressure.

The myocardial performance index (MPI), also called the Tei index, was calculated by (IVRT + IVCT) / ejection time.

Echocardiogram readers who analyzed the data were blinded to the result of treadmill and subjects' clinical information.

Right ventricular free wall longitudinal strain (RVLS_FW) and strain rate were derived from the average of three regional strains comprising the lateral wall.

Statistical methods

Data management and statistical analysis was done using SPSS vs.20. Numerical data was summarized as means and standard deviations. Categorical data was summarized as frequencies and percentages. Comparison between two groups for numerical variables were done using Mann Whitney U test. Categorical variables were compared using Chi-square test.

Correlation analysis was done using Pearson or Spearman correlation if appropriate. "r" is the correlation coefficient. It ranges from -1 to +1. -1 indicates strong negative correlation while +1 indicates strong positive correlation. 0 indicates no correlation.

All p values were two sided. P value less than 0.05 is considered significant [8].

3. Results

The mean age of the whole population was 49 ±12.56 years with maximal age of 76 years and minimal age of 21 years, while as regard sex, of the fifty patients, there were 28 males (56%) and 22 females (44%).

Between groups analysis showed significantly lower age in group A than group B (42.96 ±12.26 vs. 56.96 ±8.35, $p < 0.001$). As regarding sex distribution, both groups were of comparable. Group A include 12 males (48%) and 13 females (52%) while group B included 16 (64%) males and 9 (36%) females (p value >0.05).

Comparison of resting heart rate, blood pressure readings at presentation, maximum heart rate reached during exercise test and METs achieved revealed statistically significant difference between both groups as illustrated in Table 1.

Echocardiographic parameters:

On comparing conventional echocardiographic measurements in the two studied groups, right ventricular diameters (basal, mid cavity and longitudinal) were significantly decreased in healthy individuals (group A) (2.84 ±0.50 vs. 3.62 ±0.56 cm with p value 0.002, 2.07 ±0.58 vs. 2.23 ±0.32 cm and 4.93 ±0.68 cm vs. 5.20 ±0.74 cm, respectively p value <0.001) (Table 2 and Figure 1).

Tricuspid valve E' and S' velocities were significantly increased in group A (13.02 ±2.31 vs. 9.98 ±1.59 and 12.17 ±2.34 vs. 8.22 ±1.37 respectively p value < 0.001). While tricuspid valve A' velocity was significantly decreased in group A (12.39 ±2.20 vs. 14.11 ±2.77, p value <0.001). RV-MPI was significantly decreased in group A than group B (0.53 ±0.11 vs 0.62 ±0.13 with p value 0.004) (Table 3).

Speckle tracking echocardiography:

RVGLS was significantly increased in group A (-21.12 ±3.45 vs. -14.53 ±1.93, p value <0.001) (Table 4 and Figure 2). Also, LVGLS was significantly increased in group A (-27.86 ±1.13 vs. -19.86 ±4.34, p value <0.001) (Table 4).

Right ventricular global longitudinal strain (RVGLS) showed significant positive correlation with age (r =0.506), RV diastolic and systolic areas (r =0.613, r =0.539), tricuspid E/A ratio (r =0.501), RV-MPI (r = 0.392) and LVGLS (r = 0.670). While it showed significant negative correlation with METs (r = -0.321), Exercise time (r = -0.205), TAPSE (r = -0.432), FAC (r = -0.572) and LV ejection fraction (r = -0.794) (

Table 5 and Figure 4 up to Figure 6).

The areas under the ROC curves for the predictor of impaired functional capacity which represented in patients of group B with compensated HFrEF were 0.914 for RVGLS-FW (Figure 3).

Table 1: comparison between groups regarding clinical and exercise data:

	Group A n=25	Group B n=25	P-value
Resting heart rate (bpm)	74.28 ±7.66	81.5 ±10.5	<0.001
SBP (mmHg)	129.96 ±17.65	142.80 ±22.83	<0.001
DBP (mmHg)	75.96 ± 8.01	88.44 ±8.61	<0.001
Maximum heart rate (bpm)	157.0 ±10.11	147.04 ±9.72	<0.001
METs	10.20 ±2.16	7.92 ±1.91	<0.001
Exercise time (min)	7.94	5.80	<0.001

Table 2: Conventional echocardiographic parameters:

	Group A (healthy) N= 25		Group B (HFrEF) N= 25		P value
	Mean	±SD	Mean	±SD	
RV systolic area	10.97	4.54	19.17	2.48	< 0.001
RV diastolic area	16.92	3.16	22.69	2.04	< 0.001
RVD1 (basal) (cm)	2.84	0.50	3.62	0.56	0.002
RVD2 (mid) (cm)	2.07	0.58	2.23	0.32	< 0.001
RVD3 (long.) (cm)	4.93	0.68	5.20	0.74	< 0.001
PAP (mmHg)	28.02	7.72	46.53	9.74	< 0.001
FAC (%)	46.11	6.98	40.43	4.50	< 0.001
RV EF (%)	54.3	2.8	50.6	7.1	0.051
TAPSE (CM)	2.45	0.25	2.31	0.23	< 0.001
TV E	64.14	18.21	36.09	6.30	< 0.001
TV A	42.90	8.71	63.66	10.13	< 0.001
TV E/A ratio	1.42	0.26	1.21	0.27	< 0.001
LV EF %	65.14	6.90	34.96	4.57	< 0.001

Table 3: Tissue Doppler echocardiographic parameters:

	Group A (healthy) N= 25		Group B (HFrEF) N= 25		P value
	Mean	±SD	Mean	±SD	
E’	13.02	2.31	9.98	1.59	< 0.001
A’	12.39	2.20	14.11	2.77	< 0.001
S’	12.17	2.34	8.22	1.37	< 0.001
E\e’	367.77	1812.13	5.40	1.46	< 0.001
RV-MPI	0.53	0.11	0.62	0.13	< 0.004

Table 4: Speckle tracking echocardiography:

	Group A (healthy) N= 25		Group B (HFrEF) N= 25		P value
	Mean	**±SD**	**Mean**	**±SD**	
RVLS-FW	-21.12	3.45	-14.53	1.93	< 0.001
LVGLS %	-27.86	1.13	-19.86	4.34	< 0.001

Table 5: Correlation between RVGLS and other parameters:

	RVGLS	
	r	P value
Age (years)	0.506	< 0.001
METs	-0.321	0.023
Exercise time (min)	-0.205	< 0.001
RV diastolic area	0.613	< 0.001
RV systolic area	0.539	< 0.001
TAPSE	-0.432	0.002
RV-MPI	0.392	0.005
Tricuspid E/A ratio	0.501	< 0.001
FAC	-0.572	0.002
LVEF%	-0.794	< 0.001
LVGLS %	0.670	< 0.001

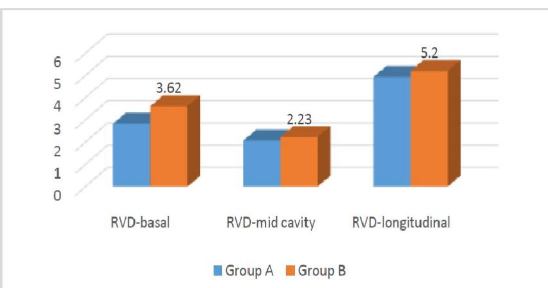

Figure 1: comparison between study groups RV dimensions

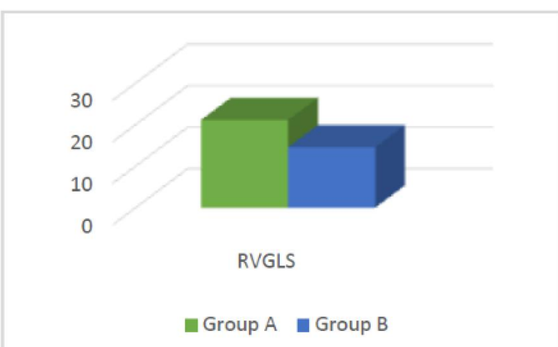

Figure 2: Comparison of RVGLS in study groups.

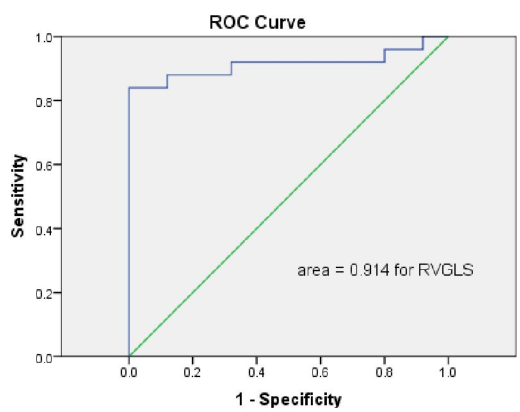

Figure 3: ROC curve for RVGLS.

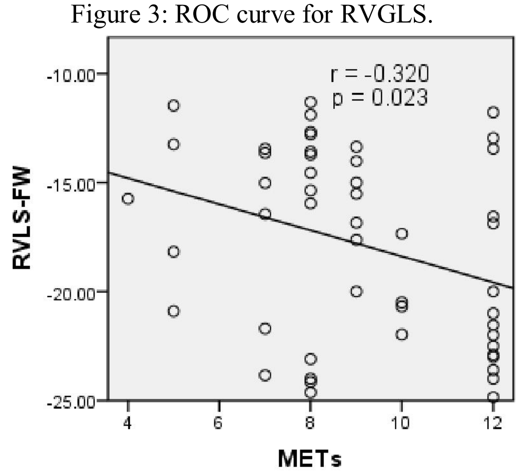

Figure 4: Correlation between RVGLS and METs

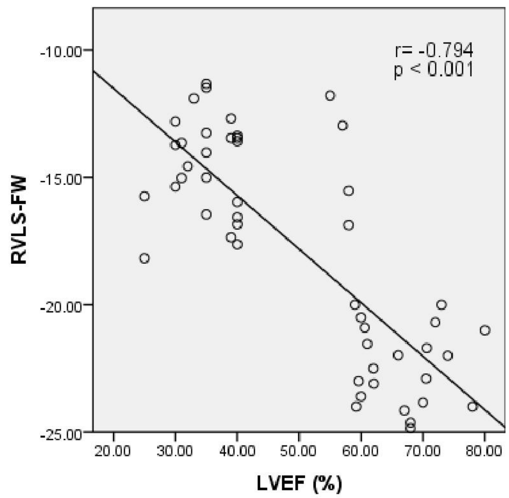

Figure 5: Correlation between RVGLS and LVEF

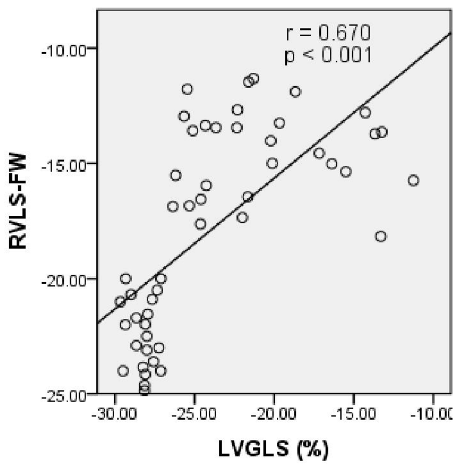

Figure 6: Correlation between RVGLS and LVGLS

4. Discussion

This study prospectively recruited subjects from a routine health examination or heart failure patients presented for regular checkup. RV function represented by RV strain was derived from speckle tracking echocardiography in addition to traditional echocardiography parameters. Functional capacity was determined by a symptom limited treadmill exercise test with the Bruce protocol.

As mentioned before, right ventricular (RV) function has been found to be a major factor of exercise capacity in patients with heart failure**[9]**. We aimed to assess functional capacity in HFrEF patients as well as healthy individuals using RV strain pattern and other diameters to detect the most reliable parameter.

Between groups analysis showed significantly lower age in group A than group B, with no significant difference in sex distribution. These findings were concordant with Chang et al.[10] and D'Andrea et al.[11] and discordant with Sljivic et al. [12]. This discordance can be attributed to different population study where Sljivic et al. studied RV function and exercise capacity in heart failure patients only divided on basis of pulmonary function tests.

In our study, comparison of study groups regarding initial clinical assessment of resting heart rate, blood pressure, maximum heart rate, METs and exercise time all were significantly lower in group A healthy individual except for METs and exercise time where they were higher in the same group (

	Group A n=25	Group B n=25	P-value

Resting heart rate (bpm)	74.28 ±7.66	81.5 ±10.5	<0.001
SBP (mmHg)	129.96 ±17.65	142.80 ±22.83	<0.001
DBP (mmHg)	75.96 ± 8.01	88.44 ±8.61	<0.001
Maximum heart rate (bpm)	157.0 ±10.11	147.04 ±9.72	<0.001
METs	10.20 ±2.16	7.92 ±1.91	<0.001
Exercise time (min)	7.94	5.80	<0.001

Table 1). These findings were discordant with Chang et al.[10] where concluded that no significant difference between groups regarding aforementioned clinical parameters except for exercise time was significantly lower in low functional capacity group.

These contradictory findings can be referred to the following; Chang et al. studied only apparently healthy individuals presented to routine health checkup and divided them according to their functional capacity in METs (8 and above in group I while less than 8 in group II), in our study; we compared such healthy individual persons with patients of reduced ejection fraction.

We founded that, mean METs comparison in both groups (10.2 ±2.16 vs 7.92 ±1.91, p <0.001) was significant and this were concordant with Chang et al. where concluded 8 METs as a cutoff value between low and normal functional capacity individuals.

In our study we found that regarding conventional echocardiographic measurements, right ventricular diameters (basal, mid cavity and longitudinal) and right ventricular areas (systolic and diastolic) were significantly decreased in healthy individuals (group A) (Table 2). FAC of the right ventricle and Tricuspid valve E wave velocity and tricuspid E/A ratio were significantly increased in healthy individual group A patients. While tricuspid valve A wave velocity was significantly decreased in the same group. Finally, RV ejection fraction had no significant statistical difference between both groups (Table 2).

The above-mentioned findings regarding conventional echocardiographic parameters were discordant with Chang et al.[10] and Sljivic et al.[12] as they studied and compared findings in only healthy individuals or heart failure patients respectively. But in our study, we compared findings in healthy individual (group A) with that of HFrEF patients (group B).

Because of same rationale, our findings regarding tissue Doppler parameters were discordant with Chang et al. and Sljivic et al. where tricuspid valve E' and S' velocities were significantly increased in group A while tricuspid valve A' velocity and RV-MPI were significantly decreased in group A than group B (see Table 3).

Finally, our results regarding RVGLS and LVGLS were concordant with Chang et al. and Sljivic et al. where they were significantly increased in high functional capacity groups. These findings were harmonic with the correlation between speckle tracking results and functional capacity where it was negatively correlated with METs and exercise capacity in all these studies.

Conclusion:

RV strain is independently associated with functional capacity in compensated heart failure patients as well as healthy individuals. RV function should be regarded as an important factor for exercise capacity.

References

1. Myers, J., et al., *Exercise capacity and mortality among men referred for exercise testing.* New England journal of medicine, 2002. 346(11): p. 793-801.
2. Hasselberg, N.E., et al., *Left ventricular global longitudinal strain is associated with exercise capacity in failing hearts with preserved and reduced ejection fraction.* European Heart Journal-Cardiovascular Imaging, 2014. 16(2): p. 217-224.
3. Nieminen, M.S., et al., *EuroHeart Failure Survey II (EHFS II): a survey on hospitalized acute heart failure patients: description of population.* European heart journal, 2006. 27(22): p. 2725-2736.
4. Cohen-Solal, A., et al., *A non-invasively determined surrogate of cardiac power ('circulatory power') at peak exercise is a powerful prognostic factor in chronic heart failure.* European Heart Journal, 2002. 23(10): p. 806-814.

5. Lancellotti, P., et al., *Elevated plasma soluble ST2 is associated with heart failure symptoms and outcome in aortic stenosis.* PLoS One, 2015. 10(9): p. e0138940.
6. Friedberg, M.K., et al., *Relation of right ventricular mechanics to exercise tolerance in children after tetralogy of Fallot repair.* American heart journal, 2013. 165(4): p. 551-557.
7. Gökdeniz, T., et al., *The BODE index, a multidimensional grading system, reflects impairment of right ventricle functions in patients with chronic obstructive pulmonary disease: a speckle-tracking study.* Respiration, 2014. 88(3): p. 223-233.
8. StataCorp, L., *Stata survey data reference manual*. 1985, Release.
9. Matthay, R.A., et al., *Right ventricular function at rest and during exercise in chronic obstructive pulmonary disease.* Chest, 1992. 101(5): p. 255S-262S.
10. Chang, W.-T., et al., *The association between right ventricular free wall strain and exercise capacity for health check-up subjects.* PloS one, 2017. 12(3): p. e0173307.
11. D'Andrea, A., et al., *Right ventricular ejection fraction and left ventricular dyssynchrony by 3D echo correlate with functional impairment in patients with dilated cardiomyopathy.* Journal of cardiac failure, 2011. 17(4): p. 309-317.
12. Sljivic, A., et al., *Association between right ventricle two-and three-dimensional echocardiography and exercise capacity in patients with reduced left ventricular ejection fraction.* PloS one, 2018. 13(6): p. e0199439.

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