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Predictors of functional capacity in chronic heart failure: echocardiography versus six-minute walk test

Abstract

Background: Six-minute walk test (6MWT) constitutes a suitable alternative for Cardio-pulmonary exercise testing to assess functional capacity in patients with heart failure (HF). Echocardiography has always been considered as the most useful easy test for evaluation of these patients.

Purpose: To determine the echocardiographic predictors of six-minute walk distance (6MWD) in patients with chronic systolic heart failure as an objective assessment of functional capacity.

Patients: This study included 40 patients with HF (EF <40%) presenting to Ain Shams University hospital heart failure clinic with grade I to II NYHA (New York Heart Association) classification. All performed simultaneous transthoracic echocardiographic study and 6MWT.

Results: The mean 6MWD was 340.25 ± 88.64 meters. 26 patients (65%) walked more than 300 meters (group I) while 35% (14 patients) did not (group II). Right ventricular systolic pressure (RVSP) and E/e' were significantly higher in (group II), (p=0.04 and 0.05 respectively). There were significant negative correlations between 6MWD and each of LVESV (r=-0.34, p=0.03), E/e'(r=-0.36, p=0.02) and, RVSP (r=-0.34, p=0.03). Linear regression analysis showed RVSP as the only independent predictor of 6MWD, thus an independent predictor of functional capacity in HF patients. Further more this study suggested a predictive model of estimation of 6MWD from a given value of RVSP: 6MWD = a + (b x RVSP); (a and b are constants) with a standard error of ±42 m.

Conclusion: RVSP, LVESV and E/e' were correlated with 6MWD in chronic HF patients. Among different echocardiographic parameters, RVSP can be used as an independent predictor of functional capacity in HF patients. Further studies are still needed to ascertain the sensitivity and specificity of this model in prediction of functional capacity in HF patients in everyday practice.

Keywords: six-minute walk, echocardiography, heart failure, functional capacity

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Abbreviations: HF, heart failure; 6MWT, six-minute walk test; 6MWD, six-minute walk distance; NYHA, New York heart association; CPE, cardiopulmonary exercise; ECG, electrocardiogram; TTE, transthoracic echocardiography; LVEF, left ventricular ejection fraction; LAD, left atrial dimension; AP, anteroposterior; IVRT, isovolumic relaxation time; DT, deceleration time; MR, mitral regurgitation; IVC, inferior vena cava; TAPSE, tricuspid annular plane systolic excursion; ATS, American thoracic society; SPSS, statistical package for social science; BMI, body mass index; ICM, ischemic cardiomyopathy; DCM, dilated cardiomyopathy; LVESD, left ventricular end systolic diameter; LVEDD, left ventricular end diastolic diameter; LVESV, left ventricular end systolic volume; LVEDV, left ventricular end diastolic volume; LAD, left atrial diameter; DT, deceleration time; IVRT, isovolumic relaxation time; TAPSE, tricuspid annular excursion; RVSP, right ventricular systolic pressure

Introduction

Echocardiography is the single most useful diagnostic test in the evaluation of patients with HF;[1] it is widely available, rapid, non-invasive and safe, and provides extensive information on cardiac anatomy (volumes, geometry, and mass), wall motion, and valvular function.[2] However it is not sensitive enough for assessment of exercise capacity as shown in previous work.[1] Methods of assessment of functional capacity are either subjective or objective. Subjective methods include: New York heart Association (NYHA) criteria, and Self-report questionnaires such as The Duke Activity Status Index.[3] There is increased need for more reliable modalities for the objective evaluation of functional exercise capacity. The most popular clinical exercise tests in order of increasing complexity are stair climbing, a Six-minute walk test (6MWT), a shuttle-walk test, a cardiac stress test (e.g., Bruce protocol), and a cardiopulmonary exercise (CPE) test.[4]

CPE test is generally regarded as the gold standard of aerobic assessment.[5] The distance walked over 6 minutes is an alternative measure of function. Compared with the costs and logistical challenges of CPE testing, 6MWT is considered significantly less expensive and more convenient. The 6MWT is a practical simple test that requires a 30 meters hallway but no exercise equipment or advanced training for technicians. The test measures the distance that a patient can quickly walk on a flat, hard surface in a period of 6 minutes (the 6MWD). It evaluates the global and integrated responses of all the systems involved during exercise.[4]. In Several published reports, 6MWT was found to be correlated with maximum oxygen consumption (VO_2max)[5–9] and provided useful prognostic information for all cause hospitalization and possibly mortality among stable NYHA functional class II and III HF patients receiving state of the art therapy 6,[10–15] These data suggest that a 6MWT may be substituted for CPE testing as an inexpensive, practical clinical tool to help gauge prognosis in the large and growing HF population. The aim of this study is to assess the echocardiographic parameters that correlate with the six-minute walk distance as an objective measure of functional capacity of patients with chronic stable HF.

Patients and methods

Forty patients with chronic heart failure referred to the cardiac rehabilitation unit at Ain Shams University hospital, Cairo, Egypt were enrolled in this study in the period from January to July 2014. Before inclusion, an informed written consent was obtained after explanation of study protocol that was approved by our local institutional human research committee as it conforms to the ethical guidelines of the 1975 Declaration of Helsinki, as revised in 2008. All patients were subjected to thorough history taking, clinical examination, twelve lead electrocardiogram (ECG) recording and resting transthoracic echocardiography (TTE) using a GE vivid S5N Ver. 10.3.0 b.114 machine (Chicago, USA) with an RS3 probe, followed by the 6MWT on the same day. The same operator performed all echocardiographic examinations.

Echocardiographic assessment

Left ventricular systolic function assessment: This included measurements of LV end systolic and end diastolic dimensions (LVESD, LVEDD), Left ventricular ejection fraction (LVEF) assessment using Teichholz method and the modified Simpson method. Mitral regurgitation severity was assessed using the regurgitation jet orifice area in the LA using color Doppler imaging.[16]

Left ventricular diastolic function assessment: This included measurements of: **Left atrial dimension:** Both longitudinal (LAD3), and horizontal (LAD2) dimensions were obtained from the apical four-chamber view. Anteroposterior (AP) linear dimension (LAD 1) was obtained from the parasternal short-axis view.[17]

Mitral inflow velocities: The peak early filling (E) and late diastolic filling (A) velocities, the E/A ratio, isovolumic relaxation time (IVRT) and deceleration time (DT) of early filling velocity.[18]

Assessment of severity of mitral regurgitation: Mitral regurgitation (MR) severity was graded by measuring the regurgitation jet orifice area in the LA using color Doppler imaging.[16]

Tissue doppler echocardiographic examination included measurements:

Annular systolic, early and late diastolic velocities (e',a'): TDI was performed in the apical views to acquire mitral annular velocities. Primary measurements included the systolic (S'), early diastolic (e'), and late diastolic velocities (a').[19]

E/e′ ratio: the mitral inflow E velocity to tissue Doppler e' (E/e' ratio) was computed.[20]

Right ventricular parameters

Right atrial pressure: estimated indirectly through the measurement of inferior vena cava (IVC) diameter and the degree of inspiratory collapse in the subcostal view. IVC dilatation and reduced collapse with inspiration indicates increased RA pressure, an IVC diameter>2.1 cm that collapses <50% with a sniff indicates a high RA pressure of 15 mm Hg (range: 10-20 mmHg). Whereas IVC diameter ≤ 2.1 cm that collapses >50% with a sniff suggests a normal RA pressure of 3 mmHg (range: 0-5 mm Hg). An intermediate value of 8 mm Hg (range: 5-10 mm Hg) was used for indeterminate cases.[21]

Right ventricular systolic pressure: The peak velocity of the tricuspid regurgitation (TR) jet by CW Doppler, together with systolic RA pressure were used to derive PA systolic pressure.[22]

Tricuspid annular plane systolic excursion (TAPSE): It was obtained using an M-mode cursor passed through the tricuspid lateral annulus in a four-chamber view and measuring the amount of longitudinal displacement of the annulus at peak-systole. Normal value for TAPSE: above 16 mm.[21]

Six minute walk test

The test was performed by a cardiologist blinded to the results of echocardiography according to the standard protocol.[23] Patients were informed about the aim and methods of performing the test.[24,25] We used a long, flat, straight, 30-meter corridor with marks on the wall every 3 meters. Each patient had to turn around at the end of each 30 meters to complete 1 lap at 60 meters. Patient preparation and encouragement were done according to recommendations of American Thoracic Society (ATS).[23] The Borg scale was used before and after the test to record the level of shortness of breath and level of fatigue.[26]

Before starting the test, the patients were instructed to keep on their regular anti-failure treatment and do not exercise vigorously within the last 2 hours before the test. Their blood pressure and pulse were measured and Baseline dyspnea and overall fatigue were recorded using the Borg scale.[26] The lap counter was set to zero and the timer to 6 minutes. The detailed instructions were explained to each patient orally. After explaining the instructions, the physician performed the first lap in front of the patient for demonstration. Patients were educated that the objective of the test is to walk as far as possible for 6 minutes without running or joggingwithout a warm up period. They were permitted to slow down, to stop, and to rest as necessary. Leaning against the wall while resting was allowed, but resuming walking as soon as patients were able.

Test was terminated at the end of the 6 minutes, or upon patient's refusal to continue or if continuing the test would have interfered with the patient's safety.[23] Immediately after the test termination, the patient was allowed to rest on a nearby chair and offered water, dyspnea and fatigue were recorded using Borg scale, heart rate was measured and the total distance walked was calculated.

Statistical analysis

Data were collected, revised, coded and entered to the statistical package for social science (SPSS) version 17. Qualitative data were presented as numbers and percentages while quantitative data were presented as mean, standard deviations and ranges. The Comparison between two groups with qualitative data was done using Chi-square test and/or Fisher exact test. The comparison between two groups with quantitative data and parametric distribution was done using independent t-test. Pearson correlation coefficients were used to assess the relation between two parameters in the same group. The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as the following: $P > 0.05$: Non significant, $P < 0.05$: Significant, $P < 0.01$: Highly significant.

Results

Forty patients with chronic heart failure were enrolled in this study. The study population was divided into two groups according to the walking distance achieved during the 6MWT. Twenty-six patients

(65%) achieved more than 300 meters (group I). Fourteen patients (35%) couldn't complete 300 meters (group II). The demographic and clinical characteristics of the enrolled population as well as the two groups are shown in Table 1 and their echocardiographic characteristics are shown in Table 2.

Table 1 Distribution of demographic and clinical data among enrolled patients and the two groups

All Patients			< 300 m (group II) n= 14 (35%)		> 300 m (group I) n= 26 (65%)		Chi-Square Test	
			No.	%	No.	%	X2	P-value
Age (Mean±SD)		55.63 ± 11.42	58.79±12.97		53.92±10.36		1.296	0.203
BMI (Mean±SD)		27.83 ± 4.94	28.59±6.88		27.42±3.61		0.705	0.485
Smoking (n,%)		26 (65.0%)	6	42.9 %	20	77 %	5.044	0.080
DM (n, %)		15 (37.5%)	7	50.00%	8	30.80%	1.436	0.231
HTN (n, %)		18 (45.0%)	9	64.30%	9	34.60%	3.237	0.072
Family History (n, %)		11 (27.5%)	4	28.60%	7	26.90%	0.012	0.911
Sex	Male	82.5	9	64.30%	24	92.30%	4.949	0.026
	Female	17.5	5	35.70%	2	7.70%		
Previous Hospital Admissions	None	18 (45.0%)	3	21.40%	15	57.70%	6.007	0.111
	Once	10 (25.0%)	4	28.60%	6	23.10%		
	Twice	6 (15.0%)	3	21.40%	3	11.50%		
	> 2 times	6 (15.0%)	4	28.60%	2	7.70%		
NYHA Class	Class 1	11 (27.5%)	0	0.00%	11	42.30%	8.170	0.004
	Class 2	29(72.5%)	14	100.00%	15	57.70%		
Etiology	ICM	31(77.5%)	8	57.10%	23	88.50%	5.119	0.024
	DCM	9(22.5%)	6	42.90%	3	11.50%		

NYHA: New York Heart Association; ICM: Ischemic Cardiomyopathy; DCM: Dilated Cardiomyopathy

Table 2 Comparison between both groups regarding all echocardiographic parameters

	All Patients		< 300 m (group II) n= 14 (35%)	> 300 m (group I) n= 26 (65%)	Independent t-test	
	Range	Mean ± SD	Mean ± SD	Mean ± SD	T	P-value
EF "Simpson's"	15 – 40	30.60 ± 6.91	29.79±8.22	31.04 ± 6.232	-0.542	0.59
EF "M mode"	15 – 40	31.75 ± 7.21	29.29±8.957	33.08 ± 5.844	-1.619	0.11
LVESV	56 – 256	95.68±36.4	103.43±48.48	91.50 ± 28.15	0.988	0.33
LVEDV	120 – 301	186.6± 37.27	193.64±46.24	182.81 ± 31.82	0.874	0.39
LAD1	31 – 52	40.23 ± 5.12	41.5±5.681	39.54 ± 4.76	1.162	0.25
LAD2	30 – 47	39.35 ± 5.09	39.93±5.091	39.04 ± 5.165	0.522	0.60
LAD3	32 – 68	52.15 ± 8.53	52.14±8.574	52.15 ± 8.675	-0.004	0.10
E	0.3 – 1.1	0.66 – 0.22	0.73±0.25	0.63 ± 0.20	1.442	0.16
A	0.34 – 1.87	0.83 ± 0.38	0.79±0.40	0.86 ± 0.38	-0.577	0.57
E/A	0.3 – 3.2	1.03 ± 0.71	1.201±0.8353	0.935 ± 0.6343	1.128	0.27
DT	92 – 290	178.73 ± 40.5	163.00±35.37	187.19 ± 41.18	-1.858	0.07
IVRT	50 – 148	97.3 ± 28.36	86.79±24.32	102.96 ± 29.18	-1.767	0.09
TAPSE	11 – 26	18.22 ± 3.48	17.86±4.167	18.42 ± 3.113	-0.486	0.63
RVSP	20 – 71	36.95 ± 12.36	42.5±15.29	33.96 ± 9.50	2.182	0.04
e'	0.04 – 0.15	0.08 ± 0.03	0.07±0.02	0.08 ± 0.03	-0.921	0.36

Table Continued...

	All Patients		< 300 m (group II) n= 14 (35%)	> 300 m (group I) n= 26 (65%)	Independent t-test	
	Range	Mean ± SD	Mean ± SD	Mean ± SD	T	P-value
S'	0.02 – 0.10	0.07 ± 0.02	0.06±0.03	0.07 ± 0.02	-1.920	0.07
a'	0.02 – 0.15	0.08 ± 0.04	0.08±0.04	0.09 ± 0.03	-0.716	0.48
E/e'	3 – 18.8	9.00 ± 3.70	10.59±4.753	8.15 ± 2.7315	2.076	0.0
HR before	71 - 101	80.23 ± 8.54	82.93 ± 8.398	77.0 ± 8.63	2.091	0.043
HR after	92 - 110	99.42 ± 8.32	102.21 ± 8.021	97.62 ± 8.7	1.637	0.110

EF, ejection fraction; LVESD, left ventricular end systolic diameter; LVEDD, left ventricular end diastolic diameter; LAD, left atrial diameter; DT, deceleration time; IVRT, isovolumic relaxation time; TAPSE, tricuspid annular excursion; RVSP, right ventricular systolic pressure; HR, heart rate

There was a statistically significant difference between the two groups as regards each of gender, NYHA class and type of cardiomyopathy. Generally, males walked more than females, patients with NYHA class II walked less compared to those with NYHA I, and those with dilated cardiomyopathy walked less compared to those with ischemic cardiomyopathy. Comparison between the two groups regarding the pre-6MWT heart rates revealed a significant difference (p 0.043), with patients who had higher pre-test heart rates were more likely to walk <300 m compared to those with lower heart rate. This difference was not statistically significant regarding age, body mass index (BMI), smoking, diabetes (DM), hypertension (HTN), family history, and previous hospitalization, (Table 1). No significant difference between the 2 groups regarding all Echocardiographic parameters including mitral regurgitation grades except for RVSP and E/e'(p =0.04 and 0.05 respectively) (Table 2). Six minute walk test results

The mean walking distance was 340.25 ± 88.64. Regarding the relation between 6MWD and different risk factors, this study showed a highly significant difference in the 6MWD in association with hypertension (p=0.002), NYHA class (p=0.001), type of cardiomyopathy (p=0.006), where the distance covered was shorter in hypertensive patients, NYHA class II, and those with DCM, compared to non-hypertensive, NYHA class I and ICM respectively. However, there was no statistically significant relationship between the 6 MWD and each of gender, smoking, DM, BMI, or the number of previous hospitalizations (Table 3).

Table 3 Relationship between 6MWD and different demographic and clinical risk factors

		6MWD		Independent t-test	
		Mean	SD	T	P-value
Gender	Male	350.48	89.95	1.618	0.114
	Female	292.00	68.01		
Smoking	Non smoker	303.43	77.32	2.496	0.096
	Smoker	378.08	89.40		
	Ex-smoker	344.64	89.60		
Diabetes	Negative	352.92	96.22	1.173	0.248
	Positive	319.13	72.47		
Hypertension	Negative	377.73	90.99	3.313	0.002
	Positive	294.44	61.30		
Family history	Negative	340.07	92.26	0.021	0.984
	Positive	340.73	82.53		
Previous hospitalizations	Non	372.17	87.21	2.422	0.082
	Once	343.90	85.58		
	Twice	301.83	70.35		
	> 2 times	276.83	83.70		
NYHA class	Class I	415.64	65.73	3.857	0.001
	Class II	311.66	79.51		
Cardiomyopthy	ICM	360.52	81.33	2.934	0.006
	DCM	270.44	80.15		

6MWD: Six Minute Walk Distance; NYHA: New York Heart Association; ICM: Ischemic Cardiomyopathy; DCM: Dilated Cardiomyopathy

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Correlation between 6MWD and different echocardiographic parameters

There were significant negative correlations between 6MWD and each of LVESV (r= -0.34, p= 0.03), E/e'(r=-0.36, p=0.02) and, RVSP (r=-0.34, p=0.03) (Figures 1–3) respectively. However, no statistically significant correlation was detected between 6MWD and EF, LVEDD, LVEDV, Left atrial dimensions, mitral inflow E velocity, A velocity, E/A ratio, DT, IVRT, TAPSE, Mitral (e', a', S') by tissue Doppler as shown in (Table 4). Using linear regression analysis among the echocardiographic variables that correlated with 6MWD showed that RVSP is the only independent predictor of 6 minute walking distance (Table 5).

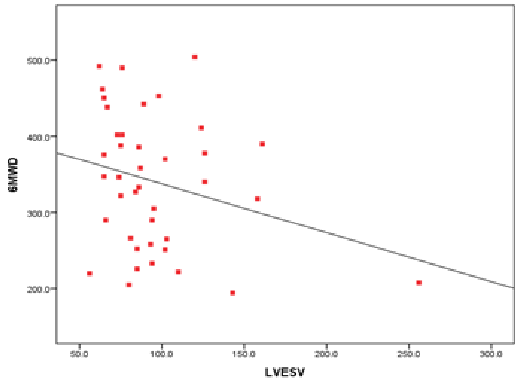

Figure 1 A plot chart showing the inverse correlation between LVESV and 6MWD.

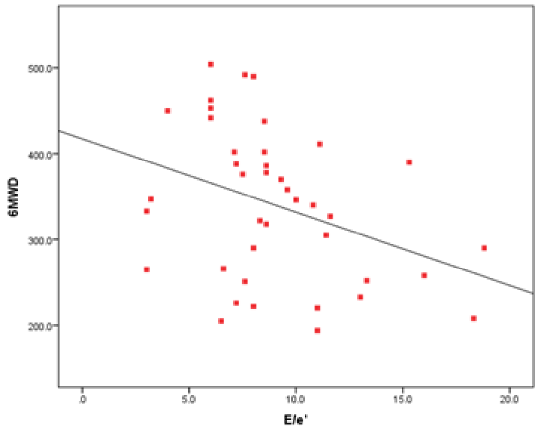

Figure 2 A plot chart showing the inverse correlation between E/e' and 6MWD.

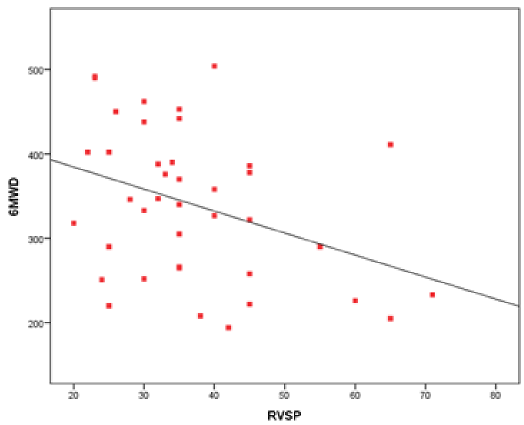

Figure 3 A plot chart showing the inverse correlation between RVSP and 6MWD.

Table 4 Correlation between 6MWD and different echocardiographic parameters

Parameter	6MWD	
	R	P-value
EF "Simpson's"	0.11	0.51
EF "M mode"	0.23	0.15
LVESD	-0.34*	0.03
LVEDD	-0.29	0.07
LVESV	-0.34*	0.03
LVEDV	-0.19	0.25
LAD1	-0.24	0.13
LAD2	-0.23	0.16
LAD3	-0.04	0.80
E	-0.11	0.51
A	0.11	0.49
E/A	-0.09	0.57
DT	-0.19	0.25
IVRT	0.18	0.27
TAPSE	0.15	0.35
RVSP	-0.34*	0.03
e'	0.24	0.14
S'	0.24	0.14
a'	0.08	0.63
E/e'	-0.36*	0.02

EF, ejection fraction; LVESD, left ventricular end systolic diameter; LVEDD, left ventricular end diastolic diameter; LVESV, left ventricular end systolic volume; LVEDV, left ventricular end diastolic volume; LAD, left atrial diameter; DT, deceleration time; IVRT, isovolumic relaxation time; TAPSE, tricuspid annular excursion; RVSP, right ventricular systolic pressure

Table 5 Linear regression analysis for 6MWD

	Unstandardized Coefficients		Standardized Coefficients	T	Significance
	B	Std. Error	Beta		
(Constant)	477.201	69.512		6.865	0.000
E/e'	-5.815	3.941	-0.243	-1.476	0.149
RVSP	-2.631	1.112	-0.367	-2.366	0.024
LVESV	-0.658	0.495	-0.27	-1.329	0.192
LVEDV	0.405	0.473	0.17	0.856	0.398

6MWD, six minute walk distance; RVSP, right ventricular systolic pressure; LVESV, left ventricular end systolic volume; LVEDV, left ventricular end diastolic volume

Assessing the possibility of estimation of the 6MWD value from RVSP

By applying the linear regression approach to the measured values of RVSP and 6MWD, a predictive model to the observed data was fitted. After applying such a model, if an additional value of RVSP is given, this model can be used to make a prediction of the value of

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6MWD with a standard error of ± 42 m (Table 2,4).

The predictive model: 6MWD=a+(b×RVSP)

Where a and b are constants)

$$6MD = 436.624 + (-2.608 \times RVSP)$$

With a standard error of ± 42 m.

Discussion

In our study, the mean 6MWD was 340m with a standard deviation of 88m. In a small study done on 22 patients with HF, the mean 6MWD was 347.1 ± 95.4m.[27] Ingle et al.,[28] found a mean 6MWD in patients with LV dysfunction of 337 ± 103 m compared to a mean of 391 ± 106m in patients without major structural heart disease. Guazzi et al.,[4] found a mean 6MWD of 350.7 ± 92.8m among 253 HF patients. However, in some other studies, the mean 6MWD was much higher than these figures, reaching and even exceeding 400 m.[14,29,30] This variability was due to variation in the population sampled, type and frequency of encouragement, corridor length, and number of practice tests as well as variation in patients' demographic data and NYHA classification.

Correlation between demographic data and 6MWD

Ingle et al..,[28] concluded that independent predictors of poor walking performance (≤300 m) in patients with LV dysfunction included age >75 years; low BMI (<20); resting heart rate >80 bpm; and being female. These results are comparable to our study where poor walking performance < 300 m was associated with high resting heart rate (mean heart rate > 82) and being a female. However, in our study there was no statistical significance between either age or BMI and 6MWD. This can be attributed to the difference in demographic data of the study population and less number of cases in our study. Frankenstein[29] tried to assess the correlation between 6MWD and each of age, weight, height and BMI. In this study the demographics of the study population was very close to ours with a mean age of 54.9±11.5 years and 80.2% of patients being males. They found a significant negative correlation between 6MWD and each of age, weight and height; however the correlation between 6MWD and BMI was not statistically significant. Also, there was no statistically significant difference in the 6MWD between both genders. In our study, we couldn't prove a significant correlation between either 6MWD and age or 6MWD and BMI. This difference may be attributed to the relatively small number of patients in our study. Correlation between Echocardiographic parameters and functional capacity, assessed by 6MWD: In our study there was a significant negative correlation between each of LVESV, E/e', RVSP and 6MWD. Among these, RVSP was the only independent predictor of 6MWD and thus poor functional capacity in HF patients. Consequently, linear regression analysis was used to formulate an equation to estimate 6MWD from RVSP.

The correlation between RVSP and functional capacity is consistent with the results obtained by Darahim.[31] The author concluded that those with RV dysfunction "higher RVSP, lower TAPSE and lower peak systolic tricuspid annular TDI" had worse functional capacity. In addition, Darahim[31] found lower LVEF, mitral DT, mitral TDI S'& mitral TDI a' together with higher LA diameter and mitral E/A ratio in the group with outcome events. These parameters were also assessed in our study, but no statistically significant correlation with 6MWD was found.

In contrast to the current study Berisha[32] found a strong correlation between LVEF and 6MWD. In our study, we had a significant negative correlation between E/e' and 6MWD (r=-0356, p<0.05). A similar result was reached by Bajractari et al.,[33] and Ibrahimi. Bajractari concluded that "In HF patients, the higher the filling pressures, the poorer is the patient's exercise capacity and the less the 6MWD". In multivariate analysis, Bajractari and his colleagues found that E/e' independently predicted exercise performance in HF patients. In Ibrahimi's study, the correlation between E/e' and 6MWD (r=-0.37, p <0.001) was very close to the correlation reached in our study (r=-0356, P <0.05). However, in contrast to our study, Ibrahimi found a significant positive correlation between each of e' and TAPSE and 6MWD (r= 0.41 and 0.45 respectively, p <0.05).[28]

The study conducted by Daullxhiu et al.,[34] found a significant correlation between each of age, hypertension, E wave and e' wave and poor exercise capacity "6MWD < 300 meters". In our study, hypertension was more prevalent among patients who walked less than 300 meters, however age, E and e' didn't vary significantly between both groups. According to this study, it is not the left ventricular ejection fraction alone that matters as a predictor for functional capacity in chronic systolic heart failure patients. This study highlights the impact of a raised right ventricular systolic pressure as a strong independent parameter that influences exercise performance in these patients, and hence consequent alert during their clinical assessment is highly required to assess the right ventricular performance meticulously and to modify their management accordingly to improve their exercise capacity.

RV dysfunction in HF may be secondary to pulmonary venous hypertension, degree of myocardial involvement and/or ischemia, ventricular interdependence, and neurohormonal interactions. RV dysfunction appears to be more common in cardiomyopathy of non-ischmic origin and more closely parallels LV dysfunction.[35] Many factors influence RV adaptation to disease. The most important factors appear to be the type and severity of myocardial injury or stress, the time course of the disease, and the time of onset of the disease process. Other important factors may include of neurohormonal activation, altered gene expression, and the pattern of ventricular remodeling.[36] Ventricular interdependence also plays an important role, where RV dilatation and/or pressure overload cause a leftward shift of the septum, changing LV geometry; RV dilatation also may increase the constraining effect of the pericardium. These changes contribute to reduction of cardiac output by decreasing LV distensibility and preload.[37]

Study limitations

It is a single small medical center study with small percentage of females. It was only limited to patients with NYHA (I) and NYHA (II). The study used 6MWT as a predictor of functional capacity, further evaluation by cardiopulmonary function test machines, which is the gold standard technique for measuring Vo_2 max is needed.

Conclusion

The 6MWT is a simple cheap tool that can be used to assess functional capacity in patients with HF. LVESV, E/e' and RVSP can be used as simple, bedside, surrogate measurements to indicate the functional capacity of patients with chronic stable HF. Further studies are still needed for further assessment of the value of different echocardiographic parameters of systolic and diastolic dysfunction (including flow propagation velocity, myocardial performance index "TEI index", strain, strain rate and ventricular dyssynchrony) in evaluation of functional capacity in HF patients. Larger scale studies involving more patients and conducted in multiple centers are needed to correlate RVSP and 6MWD as an indicator of functional capacity

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in HF patients and to further evaluate and validate the suggested predictive model for predicting 6MWD from a given value of trans mitral RVSP.

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Conflicts of interest

The authors state that there is no conflict of interest.

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