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Assessment of functional capacity of patients with chronic heart failure by the use of echocardiography right atrial volume index

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***Abstract*---**Introduction: Heart failure (HF) is a chronic syndrome that influences survival & quality of life. over the past 20 years, hospitalizations for heart failure have almost tripled, making heart failure the most common cause of hospitalization. Objective: evaluation of relationship between functional capacity by duke activity status index(DASI) in chronic heart failure patients and the right atrial volume index. Materials and methods: study was conducted on 40 patients who were admitted in the hospital with heart failure. All patients were subjected to detailed history, physical examination, electrocardiography, laboratory investigations, 2D echocardiography & tissue Doppler imaging and assessment of functional capacity using DASI. Results: Out of 40 patients, 10 (25%) had DASI<10 and 30 (75%) patients had DASI>10, according to functional capacity between the two groups, group I Vo2 peak (ml/min) mean is 12.98±1.45 and DASI score ranged from (4.5-9.95) with a median 8.6 , in group II Vo2 peak (ml/min) mean is 21.89±4 and DASI score ranged from (23.3-36.7) with a median 28.7with p value <0.001. RAVI had a significant correlation between the two groups with p value <0.001. Also, DASI have a strong correlation with RAVI (r=1.139 & p=0.029). Conclusions: RAVI predicts functional capacity in chronic stable heart failure patients.

***Keywords*---**functional capacity, right atrial volume index.

Introduction

Patients with congestive heart failure (CHF) still have a poor prognosis, even after recent advances in therapy. Therefore, it is important to establish a reliable means of identifying those patients at higher risk. So the identification of patients with heart failure at higher risk of death has become an area of active investigation over the last two decades (Solomon et al., 2005). Right ventricular (RV) systolic dysfunction is a common abnormality in patients with heart failure. Recently, a number of studies have provided evidence that right ventricular function is an independent prognostic factor in patients with moderate to severe heart failure (de Groote et al., 1998). More recently, the role of the right ventricle in the clinical presentation of the heart failure syndrome has been emphasized. Right ventricular systolic dysfunction is associated with poor long term prognosis (Spinarová et al., 2005). We aimed to evaluate the relationship between functional capacity (using duke activity status index) in patients with chronic heart failure and the right atrial volume index (RAVI).

Materials and Methods

Patient population

This study is a single center prospective study conducted on a convenient sample of 40 patients heart failure patients admitted at Tanta University Hospital for assessment of functional capacity by Echocardiography. The study protocol was formally reviewed and approved by the ethics committee for human research at Tanta Faculty of Medicine with informed consent obtained from all participants prior to commencement of the study after thorough explanation of the study objectives.

Inclusion criteria

Adult male or female >18 years old, stable, ejection fraction less than 45% with history of known heart failure due to ischemic or non-ischemic heart disease.

Exclusion criteria

Patients with, recent acute coronary syndrome (≤ 30 days), pulmonary edema or decompensation of heart failure, cardiac resynchronization devices, permanent pacemakers, valvular heart disease, severe renal failure requiring dialysis and malignancy were excluded from our study. After dropping out participants with exclusion criteria, 40 patients completed the study (this number was considered suitable enough sample for statistical analysis with significant results and correlations).

Methods

All patients were subjected to detailed history, including CAD risk factors, physical examination, Electrocardiography (ECG) and laboratory investigations included, complete blood picture, kidney function and lipid profile. The patients were divided into two groups depending on their DASI score; 10 (25%) patients

had DASI<10 and 30 (75%) patients had DASI>10. Transthoracic echocardiographic study (TTE) is done for each patient using machine vivid 7– dimension (GE Vingmed, Horten, Norway) all acquisitions were performed with a broad band M4s transducer. Imaging was performed in the standard para-sternal views and apical views with the patient in the left lateral position (according to the American society of echocardiography).

Assessment of right ventricular Ejection Fraction

EF is the fraction of chamber volume ejected in systole (stroke volume) in relation to the volume of the blood in the ventricle at the end of diastole (end-diastolic volume). SV is calculated as the difference between EDV and end systolic volume (ESV).

- TAPSE or tricuspid annular motion (TAM): which represents longitudinal function of the right ventricle. TAPSE was acquired from a standard apical 4-chamber window by placing an M-mode cursor through the Tricuspid lateral annulus (Renkin & Tucker, 1996).
- By tissue Doppler imaging (TDI) – derived tricuspid lateral annular systolic velocity: Peak systolic velocity of tricuspid annulus by pulsed wave TDI (cm/sec), obtained from the apical approach, in the view that achieves parallel alignment of Doppler beam with RV free wall longitudinal excursion (Renkin & Tucker, 1996).

Assessment of right atrial volume

- Biplane area length method using four chamber views twice (4c-4c) (Ebtia et al., 2015)
- Biplane area length method but using the four-chamber view and subcostal views (4c-subcostal) (Ebtia et al., 2015).
- Single plane Simpson's method of disks (Simpson's) (Ebtia et al., 2015).
  For all previous three methods, for patients in sinus rhythm, 3 cardiac cycles are used and then averaged. For the patients in atrial fibrillation, 5 cardiac cycles are used, and the values averaged (Ebtia et al., 2015). The recommended parameter to assess RA size is RA volume, The normal ranges for 2D echocardiographic RA volume are 25 ± 7 ml in men and 21 ± 6 ml in women.
- By three-dimensional echocardiography
  At the beginning of the 3D analysis workflow, RA data set is automatically sliced four-, two-chamber, and long-axis apical planes and a short-axis plane. Rapid manual data set alignment is performed by translating and rotating the four-chamber plane in order to obtain orthogonal non-foreshortened planes of the RA in all three apical views. In each apical view, the RA blood–tissue interface is manually initialized on two frames identifying right atrial V max and V min. These initialized RA endocardial boundaries are used to reconstruct the RA endocardial surface. A 3D surface of the RA volume is then generated for each frame throughout the cardiac cycle resulting in a dynamic cast of the RA cavity (Peluso et al., 2013).

For each consecutive frame, the voxel count inside the 3D RA surface was used to measure RA volume, resulting in a smooth interpolated time- volume curve from which V max, V min, and V pre A can be easily obtained (Peluso et al., 2013).

Assessment of functional capacity

By using Duke Activity Status Index (DASI), which was developed in 1989 by Hlatky et al. (Scotto, Waechter, & Rosneck, 2011). DASI is a 12-point scale that evaluates the patient's ability to perform everyday activities. A cut-off points of DASI < 10 was used to define the subgroup of patients with the lowest functional Capacity because DASI = 9.95 is achieved if the subject is able to perform activities below 3 METs, i.e., items 1, 2, 3 and 6 of the questionnaires.

Statistical analysis

Data were analyzed using Statistical Program for Social Science (SPSS) version 25.0 for windows (SPSS Inc., Chicago, IL, USA), NCSS 12 for windows (NCSS LCC., Kaysville, UT, USA). Quantitative data were expressed as mean ± standard deviation (SD). Median and inter-quartile range (IQR) were also calculated for quantitative data. Qualitative data were expressed as frequency and percentage. The following tests were done, Independent-samples t-test of significance was used when comparing between two means of normally distributed data, Mann Whitney U test is used to compare differences between two independent groups when the dependent variable is continuous, but not normally distributed, Chi-square (X2) test also called Pearson's chi-square test or the chi-square test of association, is used to discover if there is a relationship between two categorical variables and Fisher Exact test is a test of significance that is used in the place of chi square test in 2 by 2 tables, especially in cases of small samples. Receiver operating characteristic (ROC) curve analysis was used to identify optimal cut-off values. Area Under Curve (AUC) was also calculated, criteria to qualify for AUC were as follows: 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 point of maximum accuracy.

Results

The study group included 40 patients, 35 (87.5%) patients were males, and 5 (12.5%) patients were females, with a mean age of 60.3 ± 10.7years. The patients were divided into two groups depending on their DASI score; ten (25%) patients had DASI<10 and 30 (75%) patients had DASI>10. the clinical characteristics and risk factors as shown in Table I; male sex, old age, patients with diabetes mellitus, hypertension, dyslipidemia, previous myocardial infraction and positive family history were significantly higher in patients with DASI<10, smoking status showed no difference between the two groups. Table II shows the cause of heart failure between the two groups either ischemic or dilated cardiomyopathy and as regarding QRS complex either normal, LBBB or RBBB there was no significant difference with p values 0.149 and 0.298 respectively.

As regarding NYHA class, group I included 5 patients (50%) with NYHA class III, 4 patients (40%) with NYHA class II and one patient (10%) with NYHA class I while

group II included 21 patients (70%) with NYHA class I ,8 patients (26.7%) with NYHA class II and one patient (3.3%) with NYHA class III. Advanced classes of NYHA being significantly more evident in (DASI < 10) group than (DASI ≥ 10) with p<0.001, (Table II). According to the rhythm, group I included 7 patients (70%) with sinus rhythm and 3 patients (30%) with atrial fibrillation (AF) while group II included 29 patients (96.7%) with sinus rhythm and one patient (3.3%) with AF, there was significant difference between the two groups as regard to rhythm, p 0.042, (Table II).

As regarding Echo data, left ventricular ejection fraction (LVEF), TAPSE, E/e, S of RV, RVSP and RAVI were significantly high in patients with DASI>10 with p values 0.005, 0.005, 0.002, <0.001, 0.008 and <0.001respectively. Meanwhile for E/A and S wave of LV there was no significant correlation between the two groups p values 0.306 and 0.067 respectively, (Table III, Figures I, II, III and IV). Medications, including angiotensin receptor blockers (50%) was significantly high in patients with DASI<10 also, beta blockers (70%) were significantly high in patients with DASI>10 while acetyl salicylic acid, clopidogrel, angiotensin converting enzyme inhibition (ACEI), diuretics, statins and mineralocorticoid antagonist were not significant between the two groups, (Table IV).

According to functional capacity between the two groups, group I Vo2 peak (ml/min) mean is 12.98±1.45 and DASI score ranged from (4.5-9.95) with a median 8.6 while in group Vo2 peak (ml/min) mean is 21.89±4 and DASI score ranged from (23.3- 36.7) with a median 28.7. There is a statistically significant difference between the studied groups as regard to Vo2 peak and DASI score. p <0.001, (Table V, Figure V). Table VI shows univariate analysis showed that AF, TAPSE, RVSP and RAVI have a significant role in predicting DASI <10 with increasing risk by 12.429, 0.128, 1.067 and 1.082 times respectively. P <0.05.

In Table VII, DASI have a strong correlation with TAPSE (r=0.163& p= 0.046) and RAVI (r=1.139 & p=0.029) so, TAPSE and RAVI are considered independent predictors also there was a non-significant correlation between DASI and AF (r=18.621& p= 0.064) and RVSP (r=0.987 & p=0.775) Finally, ROC analysis showed that the predictive performance of RAVI (ml/m^2) for DASI analysis was 70% sensitive, 80% specific, 53.9% PPV, 88.9% NPV and 77.5% accurate. P value <0.001, (Table VIII, Figure VI).

Discussions

Right ventricular function assessment by standard echocardiography has been neglected for some time due to difficulties in visualization and quantitative assessment of the right ventricle (RV), lately it became important to assess RV function as it represent a significant predictor of morbidity and mortality in congestive HF (Pennell, 2010). On the other hand, right atrium (RA) is a simpler geometric structure and easier to non – invasively measure than RV and RA volume can serve as a quantitative marker of RV dysfunction severity (Cioffi, de Simone, Mureddu, Tarantini, & Stefenelli, 2007).

It was noticed that RA dilatation is observed at advanced stages of RV dysfunction, so it may reflect a more severe clinical presentation and course in

patients with HF-ref (Bogaard, Abe, Vonk Noordegraaf, & Voelkel, 2009). The study assessed the functional capacity of patients with chronic heart failure by the use of echocardiographic right atrial volume index (RAVI), it had been primarily evaluated and quantified by the Duke Activity Status Index (DASI) questionnaire.

According to functional capacity patients had been classified into two groups:

- Group I: Duke Activity Status Index (DASI) less than 10 (<10).
- Group II: Duke Activity Status Index (DASI) equal or more than 10 (≥10).

In the current study, according to sex and heart failure causes there was no statistically significant difference between the two groups (p value= 0.089 and p value= 0.149 respectively) This was concordant with Mantziari et al (Mantziari et al., 2013), their study included 51 patients, 20 patients with DASI <10 (5 females, 15 males,10 patients with ischemic cause of HF and 10 with non ischaemic cause of HF) and 31 patients with DASI ≥10 (6 females, 25 males, 9 patients with ischaemic cause of HF and 22 patients with non ischaemic cause of HF with no statistically significant difference between the two groups as regard to sex and heart failure cause (p value = 0.897 and p value = 0.224 respectively).

In the present study, regarding to age there was no statistically significant difference between the two groups (p value= 0.954) with mean age (60.3±SD1.6 years) and (60.1±SD 8.2 years). This is discordant with the result of Mantziari et al (Mantziari et al., 2013) whose study included 51 patients, 31 patients with DASI ≥10 and a mean age (58±16 years) and 20 patients with DASI<10 and a mean age (68±11 years). There was statistically significant difference between the two groups regarding to the age p value =0.012. As regard to other clinical data (NYHA class and rhythm), there was statistically significant difference between the two groups (p value <0.001& p value 0.042 respectively) in the present study which comes in agreement with the study made by Mantziari et al (Mantziari et al., 2013) with p value (<0.001& 0.001) respectively.

Our study stated that patients with a high functional capacity (DASI≥10) had higher left ventricular ejection fraction (LVEF) (36.2±SD 6.9), while patients with a low functional capacity (DASI<10) had lower LVEF (28.8±SD 6.3). Mantziari et al (Mantziari et al., 2013) who showed that patients with a high functional capacity (DASI≥10) had higher LVEF (30±SD 7%) versus patients with a low functional capacity (DASI<10) had lower LVEF (26±SD 6%) (p value= 0.022), which was in agreement to our results. Our results showed that patients with a low functional capacity (DASI<10) had significantly higher mitral E/e` ratio than patients with a high functional capacity (DASI≥10) (13.5±SD 5.4& 8.4±SD 3.8, p value 0.002).

This result was in agreement with the result of Hamdan et al (Hamdan et al., 2006), study, who studied the relationship of mitral annular velocities and clinical manifestation in patients with significant left ventricular(LV) dysfunction and founded that mitral E/e` ratio was independent predictor of functional class, this finding ensure the important contribution of diastolic dysfunction to the functional class.

Mantziari et al (Mantziari et al., 2013) used tricuspid E/A ratio as diastolic right ventricular parameter, there was no statistically significant difference between the two groups (group with low functional capacity (DASI < 10) and other with high functional capacity (DASI ≥ 10) and this result was in agreement with our present study that showed that there was no statistically significant difference between the two groups as regard to tricuspid E/A ratio (p = 0.306). In the present study, patients with a low functional capacity (DASI< 10) had lower peak systolic velocity of tricuspid valve annulus (S`tri) and lower tricuspid annular plane systolic excursion (TAPSE) (as systolic right ventricular parameters) (0.05 m/s, 1.34±0.7 cm respectively) versus patients with a high functional capacity (DASI ≥ 10) had higher S`tri and TAPSE (0.13 m/s, 1.94±0.51 cm respectively) (p = 0.005).

Mantziari et al (Mantziari et al., 2013) agreed with our results and showed that patients with a low functional capacity (DASI < 10) had lower TAPSE (1.4 ± 0.3 cm) versus patients with a high functional capacity (DASI ≥ 10) had higher TAPSE (2.0 ± 0.4 cm) (p < 0.001). Our study showed that patients with a low functional capacity (DASI< 10) had higher estimated right ventricular systolic pressure (RVSP) (48 mmHg) versus patients with a high functional capacity (DASI ≥ 10) had lower RVSP (27 mmHg) (p = 0.008). This is similar to the study by Mantziari et al (Mantziari et al., 2013) who showed that patients with a low functional capacity (DASI < 10) had higher RVSP (61 ± 13 mmHg) versus patients with a high functional capacity (DASI ≥ 10) had lower RVSP (40 ± 16 mmHg) (p < 0.001).

The current study stated that there was a statistically highly significant difference between the two groups as regard to RAVI, RAVI was higher in patients with a low functional capacity (DASI<10) than those with DASI≥10 (47.5ml/m^2 versus 19.5ml/m^2) with p value <0.001. In concordance to our results, Mantziari et al (Mantziari et al., 2013) showed value of right atrial volume index (RAVI) which has been studied as a predictor of functional capacity in patients with heart failure, who found that patients with a low functional capacity (DASI<10) had higher RAVI (42±15 ml/m^2) while patients with a high functional capacity (DASI≥10) had lower RAVI (22±9 ml/m^2) (p<0.001).

In the present study, correlation between DASI and RAVI was statistically highly significant negative correlation (r=1.139 and p=0.029), also there was a strong correlation between DASI and TAPSE (r=0.163 and p=0.046) and DASI and s`tri (p=<0.001), beside a week correlation with AF and RVSP. RAVI was the best predictor of DASI (r=1.139). Mantziari et al (Mantziari et al., 2013) reported that right atrial volume index (RAVI), TAPSE and reduced LVEF are independent predictors of functional capacity in patients with chronic heart failure but RAVI was a stronger predictor of functional capacity assessed by the Duke Activity Status Index in patients with stable chronic heart failure with high sensitivity and specificity in the subgroup of patients with impaired right ventricular systolic function (79% and 90% respectively) in predicting DASI < 10 and RAVI was the single independent predictor of low DASI (beta = - 0.501, p < 0.001).

Sallach et al (Sallach et al., 2009) showed that increasing tertiles of RAVI were predictive of HF hospitalization (p = 0.0002) and remained an independent predictor of adverse clinical events in patients with chronic stable heart failure after adjusting for age, brain naturetic peptide, LVEF, RV systolic dysfunction

stage, and tricuspid E/e` ratio (p = 0.005). Also showed that RAVI ≥ 41.6 ml/m^2 (optimal ROC cutoff) had a 68% sensitivity and a 92% specificity (p < 0.0004) for predicting NYHA functional class ≥ 3. Darahim K (Darahim, 2014), showed that RAVI was found to be independent predictor of adverse outcome in patients with chronic systolic heart failure with a threshold value of 29 ml/m^2. The mean RAVI was higher in patients with adverse events (45.5 ± 15 ml/m^2 versus 25.2 ± 11 ml/m^2, p < 0.001).

Hamdan et al (Hamdan et al., 2006), who studied the relationship of mitral annular velocities and clinical manifestation in patients with significant left ventricular (LV) dysfunction, showed that mitral E/e` ratio was correlated with hospitalization for worsening heart failure. In the current study, tricuspid annular plane systolic excursion (TAPSE) and peak systolic velocity of tricuspid valve annulus (S`tri) were used to assess right ventricular systolic function which are high statistically significant (p=0.005 and p=>0.001 respectively), but there was statistically weak correlation with TAPSE (r = 0.163, p = 0.046). This was comparable with the following studies:

Sallach et al (Sallach et al., 2009), founded that right ventricular systolic function was graded as normal in 58 (30%), mild in 44 (23%), moderate in 40 (21%), moderate/severe in 29 (15%), and severe in 21 (11%) subjects. As RV systolic dysfunction worsened, RAVI increased significantly. Mantziari et al (Mantziari et al., 2013) reported that RAVI had a strong correlation with right ventricular systolic function parameter (TAPSE) (r = - 0.47, p = 0.001) and right ventricular end systolic diameter (r = - 0.484, p = 0.002). Darahim K (Darahim, 2014), founded a good correlation between RAVI and worsening systolic right ventricular parameters (s`tri and RVFAC) (r=-0.59, r=-0.45 respectively and p<0.001 for both).

Conclusions

Right atrial volume index (RAVI) predicts functional capacity assessed and quantified by the Duke Activity Status Index (DASI) in patients with chronic stable heart failure.

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Tables

Table (I): Demographic data and risk factors among the studied groups

Demographic data	DASI < 10	DASI ≥ 10	Test	P-value (Sig.)
Count	10	30		
Gender				

Female	3 (30%)	2 (6.7%)	‡F	0.089 (NS)
Male	7 (70%)	28 (93.3%)		
Age (years)				
Mean ± SD	60.1 ± 8.2	60.3 ± 1.6	-0.059 *	0.954 (NS)
Risk factors				
HTN	7 (70%)	13 (43.3%)	2.133 ‡	0.144 (NS)
DM	9 (90%)	10 (33.3%)	‡F	0.066 (NS)
Smoking	7 (70%)	21 (70%)	‡F	1.000 (NS)
Family history of CAD	5 (50%)	11 (36.7%)	‡F	0.482 (NS)

* Independent samples Student's t-test. ‡F Fisher's Exact test. ‡ Chi-square test. p< 0.05 is significant. Sig.: significance

Table (II): Comparison between the studied groups regarding the clinical and ECG

Clinical and ECG data	DASI < 10	DASI ≥ 10	Test	P-value (Sig.)
Count	10	30		
Cause of HF				
DCM	2 (20%)	1 (3.3%)	‡F	0.149 (NS)
ICM	8 (80%)	29 (96.7%)		
NYHA class				
Class I	1 (10%)	21 (70%)	15.407 ‡	<0.001 (HS)
Class II	4 (40%)	8 (26.7%)		
Class III	5 (50%)	1 (3.3%)		
Rhythm				
Sinus	7 (70%)	29 (96.7%)	‡F	0.042 (S)
AF	3 (30%)	1 (3.3%)		
QRS complex				
Normal	5 (50%)	22 (73.3%)	2.420 ‡	0.298 (NS)
LBBB	4 (40%)	5 (16.7%)		
RBBB	1 (10%)	3 (10%)		

‡F Fisher's Exact test. ‡ Linear-by-linear association. ‡ Chi-square test. p< 0.05 is significant. Sig.: significance

Table (III): Comparison between the studied groups regarding echocardiographic data

Echocardiographic data	DASI < 10	DASI ≥ 10	Test	P-value (Sig.)
Count	10	30		
Ejection Fraction (%)				
Mean ± SD	28.8 ± 6.3	36.2 ± 6.9	-2.975 *	0.005 (S)
TAPSE (cm)				
Mean ± SD	1.34 ± 0.7	1.94 ± 0.51	-2.950 *	0.005 (S)
E/A				
Median (IQR)	2.1 (0.6 – 2.2)	0.7 (0.55 – 1.25)	1.042 •	0.306 (NS)
E/e´				
Mean ± SD	13.5 ± 5.4	8.4 ± 3.8	3.263 *	0.002 (S)
S of LV (m/s)				
Median (IQR)	0.05 (0.055 – 0.0725)	0.07 (0.06 – 0.08)	-1.914 •	0.067 (NS)
S of RV (m/s)				
Median (IQR)	0.05 (0.05 – 0.05)	0.13 (0.11 – 0.14)	-4.470 •	<0.001 (HS)
RVSP (mmHg)				
Median (IQR)	48 (36 – 60)	27 (19.25 – 35.25)	2.617 •	0.008 (S)
RAVI (ml/m^2)				
Median (IQR)	47.5 (27.75 – 57.75)	19.5 (18 – 27.375)	3.384 •	<0.001 (HS)

• Mann Whitney U test. * Independent samples Student's t-test. p< 0.05 is significant. Sig.: significance

Table (IV): Medications among the studied groups

Medications used	DASI < 10	DASI ≥ 10	Test	P-value (Sig.)
Count	10	30		
Drug				
Aspirin	9 (90%)	30 (100%)	‡F	0.250 (NS)
Clopidogrel	4 (40%)	19 (63.3%)	‡F	0.274 (NS)
ACEIs	6 (60%)	26 (86.7%)	‡F	0.089 (NS)
ARBs	5 (50%)	3 (10%)	‡F	0.015 (S)
BBs	7 (70%)	30 (100%)	‡F	0.012 (S)
Diuretics	6 (60%)	9 (30%)	‡F	0.135 (NS)
Statins	7 (70%)	28 (93.3%)	‡F	0.089 (NS)
MRA	1 (10%)	3 (10%)	‡F	1.000 (NS)

‡F Fisher's Exact test. ‡ Linear-by-linear association. ‡ Chi-square test. p< 0.05 is significant. Sig.: significance

Table (V): Functional capacity data among the studied groups

Functional capacity data	DASI < 10	DASI ≥ 10	Test	P-value (Sig.)
Count	10	30		
VO2 peak (ml/min)				
Mean ± SD	12.98 ± 1.45	21.89 ± 4.0	-6.828 *	<0.001 (HS)
DASI score				
Median (IQR)	8.6 (4.5 – 9.95)	28.7 (23.2 – 36.7)	4.728 •	<0.001 (HS)

‡F Fisher's Exact test. ‡ Chi-square test. p< 0.05 is significant. Sig.: significance

Table (VI): Univariate logistic regression analysis for DASI<10

Variable	Unadjusted OR	95% Confidence Interval for OR		P-value (Sig.)
		Lower Bound	Upper Bound	
AF	12.429	1.117	138.238	0.040 (S)
TAPSE (cm)	0.128	0.026	0.629	0.011 (S)
RVSP (mmHg)	1.067	1.014	1.124	0.013 (S)
RAVI (ml/m^2)	1.082	1.026	1.141	0.004 (S)

OR: Odds ratio

Table (VII): Multivariate logistic regression analysis for DASI<10

Variable	Adjusted OR	95% Confidence Interval for OR		P-value (Sig.)
		Lower Bound	Upper Bound	
AF	18.621	0.847	409.205	0.064 (NS)
TAPSE (cm)	0.163	0.027	0.970	0.046 (S)
RVSP (mmHg)	0.987	0.906	1.077	0.775 (NS)
RAVI (ml/m^2)	1.139	1.014	1.280	0.029 (S)

Table (VIII): The predictive performance of RAVI (ml/m^2) for DASI<10; ROC curve analysis

Cut-off value	SN % (95% CI)	SP % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	Accu. % (95% CI)	AUROC (95% CI)	P-value (Sig.)
RAVI ≥32 ml/m^2	70% (34.8 – 93.3)	80% (61.4 – 92.3)	53.9% (25.1 – 80.8)	88.9% (70.8 – 97.7)	77.5% (61.6 – 89.2)	0.860 (0.692 – 0.940)	<0.001

ROC curve: Receiver Operating Characteristic curve, SN: Sensitivity, SP: Specificity, PPV: Positive, Predictive Value, NPV: Negative Predictive Value, AUROC: Area Under Receiver Operating Characteristic curve, 95%CI: 95% Confidence Interval, p< 0.05 is significant, Sig.: significance.

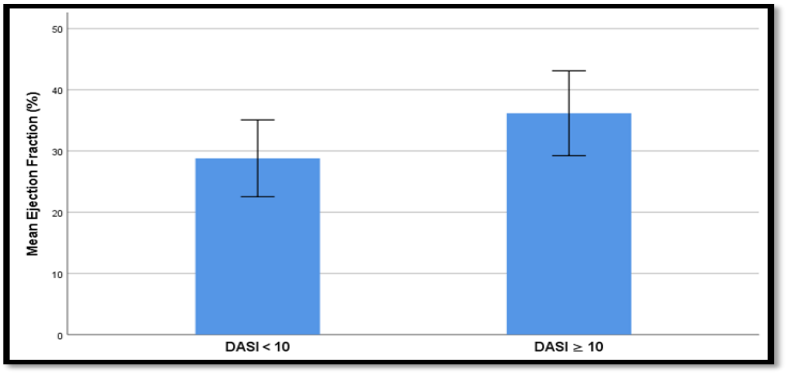

Figure (I): LVEF between the two groups

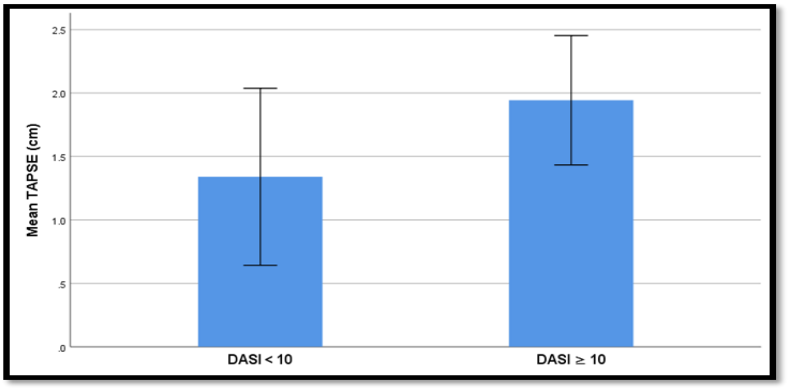

Figure (II): TAPSE between the two groups

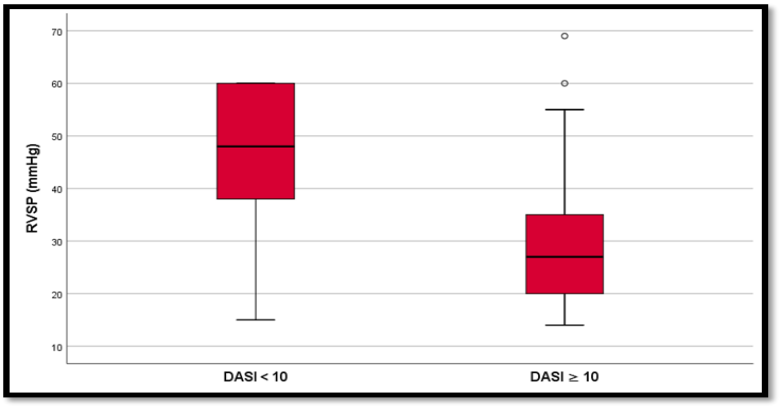

Figure (III): RVSP between the two groups

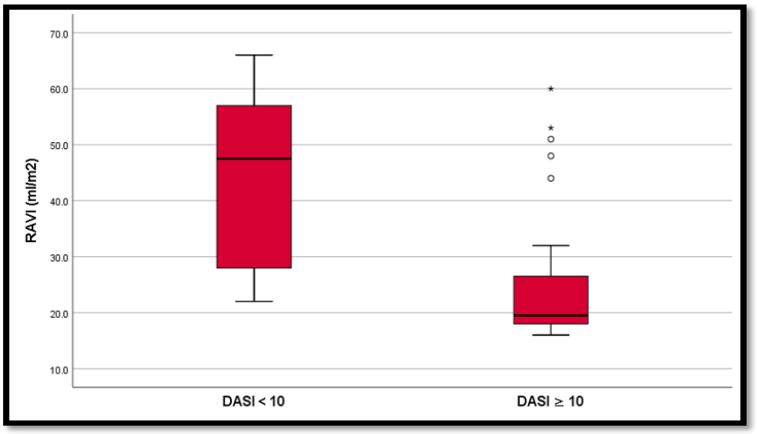

Figure (IV): RAVI between the two groups

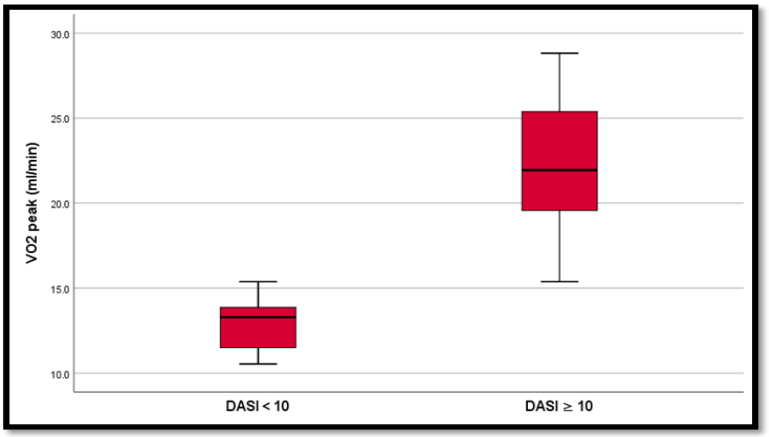

Figure (V): Functional capacity between the two groups

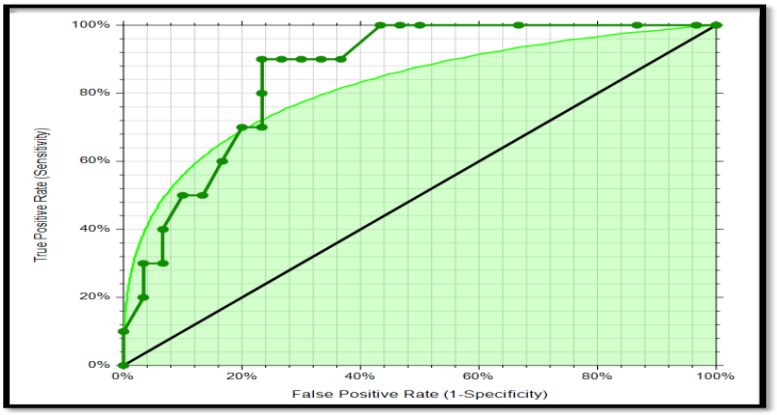

Figure (VI): ROC curve analysis for RAVI (ml/m^2) in predicting DASI<10