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Original Article

Assessment of right ventricular function by echocardiography in patients with chronic heart failure

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ABSTRACT

Background: The main focus of most of the studies in heart failure (HF) is the assessment of the left ventricular functions, while the right ventricle was much less studied. Much of this neglect is due to the complexity of anatomy and physiology of the right ventricle which are considered challenges during assessment of RV.

Objective: [1] To review the alterations of right ventricular dimensions & function associated with chronic heart failure. [2] To predict the prevalence of right ventricular systolic dysfunction in patients with chronic heart failure, based on echocardiographic parameters.

Methods: 100 chronic left sided heart failure patients with LVEF less than 40% were evaluated in Ain Shams University hospitals from April 2015 to March 2016. All patients were subjected to full history taking & clinical evaluation. **ECG** was done mainly to exclude presence of ischemic heart disease. Complete trans-thoracic echocardiography study was done for assessment of [B] Left ventricular dimensions, systolic and diastolic functions [B] Assessment of the right side of the heart: [1] Measurement of the right ventricular dimensions [basal – mid cavity and the longitudinal diameters]. [2] Right ventricular area and calculation of the fractional area change (FAC). [3] Tricuspid annular plane systolic excursion (TAPSE). [4] Tissue Doppler derived tricuspid lateral annular systolic velocity (S′ wave velocity). [5] Tissue Doppler derived Myocardial Performance Index (MPI) (Tei index). [6] Grading of tricuspid regurgitation severity, and assessment of right ventricular systolic pressure.

Results: Right ventricle was dilated at the basal level in 36% of the studied patients & at the mid cavity level in 23% of the patients. Longitudinal RV diameter was enlarged in 20% of the patients.

Right ventricular systolic dysfunction was found in 36% of patients with DCM in the current study. Patients who had right ventricular systolic dysfunction had significantly higher incidence of elevated JVP, significantly lower EF and significantly higher grade of LV Diastolic dysfunction. They showed significantly larger RV dimensions at different levels, significantly worse degree of TR and significantly higher mean value of RVSP.

Conclusions: The occurrence of right ventricular systolic dysfunction in patients with DCM is common [Approaching 40% in this study] and is independent of age and sex, and is proportionate to the degree of LV dilatation, and EF impairment.

1. Background

After ischemic heart disease as the first cause of heart failure (HF) idiopathic dilated cardiomyopathy (DCM) is the second most common. Despite all the advances in diagnosis and treatment of HF, still the outcome of heart failure patients is unpredictable mostly because many factors affect prognosis.[1] The relation between worse LV systolic function and poor outcome in heart failure is well established.[2] The new parameters of myocardial deformation by speckle tracking also have prognostic importance.[3]

Right ventricular (RV) and LV systolic dysfunction are closely related through (shared fibres and interventricular septum, most cardiomyopathies affect both ventricles, effects of elevated LV filling pressure, ventricular interdependence and limited pericardial space).[4]

The RV functional assessment remained difficult and challenging for years due to the complexity of anatomy and physiology of

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the right ventricle which are considered challenges during assessment of RV. However, structural and functional changes of the right ventricle contributes significantly to the HF syndrome.[5]

Previous studies suggested that right ventricular ejection fraction (RVEF) [assessed by radionuclide or thermo dilution] significantly affects both exercise capacity and outcome, that is why the clinical importance of RV function assessment in the HF population has been recently highlighted.[4]

Recent Advances in echocardiography helped to identify the value of RV functions in risk stratifying heart failure patients.[6] The prevalence of RV dysfunction in patients with idiopathic dilated cardiomyopathy lies somewhere between 34 and 65%.[7] Studies highlighted the prognostic importance of RV dysfunction in HF especially in idiopathic dilated cardiomyopathy.[8]

Echocardiography is a simple non-invasive, relatively cheap and available method of right ventricular assessment. Many parameters apart from the RVEF can be used for assessment of RV like tricuspid annular plane systolic excursion (TAPSE), tricuspid annular peak systolic velocity measured by tissue Doppler imaging (S′ velocity), both of which correlate well with RVEF and also the RV fractional area change (FAC).[9]

The aim of the present study was to review the echocardiographic alterations of right ventricular dimensions & function associated with chronic heart failure, and to predict the prevalence of right ventricular systolic dysfunction in patients with chronic heart failure, based on echocardiographic parameters.

2. Patients and methods

2.1. Patients

The study included 100 patients with chronic left sided heart failure "Impaired global LV systolic function with EF < 40%" referred to Ain Shams University hospitals for control of heart failure symptoms in the period between October 2015 to March 2016.

Excluded from the study; patients with rheumatic heart disease, COPD patients, patients with history of coronary artery disease or resting regional wall motion abnormalities by echocardiography and patients with ECG showing rhythm other than sinus rhythm, complete RBBB or LBBB, pacemakers or defibrillators.

2.2. Methods

The patients were subjected to detailed history taking and clinical examination with special emphasis on measurement of JVP and assessment of lower limb edema. The severity of dyspnea was assessed according to New York Heart Association (NYHA) functional class.

Transthoracic echocardiography; Conventional echocardiographic Doppler study and tissue Doppler imaging were performed using Vivid 9 (General Electric Healthcare), equipped with harmonic M4S variable frequency phased-array transducer and echo Pac software for offline analysis.

Images were obtained with patients in the left lateral position at end-expiration according to the recommendations of the American Society of Echocardiography and connected to single-lead electrocardiography (ECG).[10]

All standard measurements were obtained in the parasternal long- and short-axis views, apical four-chamber, two-chamber views, and apical long-axis view. All measurements were taken on three consecutive beats and the mean values were used. No measurements were taken within five cycles of an ectopic beat.

The following parameters were measured:

(A) *Left Ventricular dimensions & systolic function:*

We measured LV dimensions (LVEDD, LVESD, SWT & PWT) using M-mode at the paratsrenal short axis view at the level of papillary muscles, and then using the biplane (modified Simpson's method) to measure LVEDV & LVESV. *LVEF was calculated as* LVEDV − LVESV/LVEDV%.[10]

(B) *Assessment of LV diastolic function:*

Transmitral pulsed-wave Doppler was recorded, the peaks of both E and A waves were measured, and the E/A ratio and E wave deceleration time were calculated.

Offline color-coded tissue Doppler imaging was done in the apical four-chamber view by placing the sample volume over the septal and lateral mitral annuli, and then, early diastolic velocity (E'), and late diastolic velocity (A') were measured. The average E' velocities at the sepal and lateral mitral annuli were estimated, and the E/E' ratio was calculated. Accordingly LV Diastolic dysfunction was graded in each patient according to the guidelines.[11]

(C) *Assessment of the right side of the heart* According to the American Society of Echocardiography Guidelines[3]

1. RV Dimensions

RV dimensions were measured at end-diastole from a right ventricle–focused apical 4-chamber view. Three RV dimensions were measured **The basal diameter** is the maximal short-axis dimension in the basal one third of the right ventricle, **The mid cavity diameter** is measured in the middle third of the right ventricle at the level of the LV papillary muscles, and **the longitudinal dimension** is drawn from the plane of the tricuspid annulus to the RV apex.[3]

2. Assessment of the fractional area change (RVFAC)

RVFAC was obtained from the apical four-chamber view by tracing the RV endocardium both in systole and diastole from the annulus, along the free wall to the apex, and then back to the annulus along the interventricular septum (Fig. 1). RV FAC = RV end diastolic area − RV end systolic area/RV end diastolic area %.[3]

3. Measurement of the tricuspid annular plane systolic excursion (TAPSE)

TAPSE was acquired by placing an M-mode cursor through the tricuspid annulus in the apical 4 chamber view and measuring the amount of longitudinal motion of the annulus at peak systole (Fig. 2).

4. Assessment of tricuspid regurgitation (TR)

Severity of TR was assessed (**Mild:** jet area < 5 cm^2, **Moderate**: jet area 5–10 cm^2, **Severe**: jet area > 10 cm^2).[12]

Right ventricular systolic pressure was calculated by continuous-wave Doppler ultrasound examination of the maximum velocity of TR using the modified Bernoulli equation [**4 × (peak velocity of TR)^2**][13] and estimation of the mean right atrial pressure by the respiratory motion of the inferior vena cava in 2-dimensional echocardiography.[14]

5. Pulsed wave tissue Doppler imaging

All patients were examined by pulsed wave tissue Doppler imaging technique using the standard views. From the apical

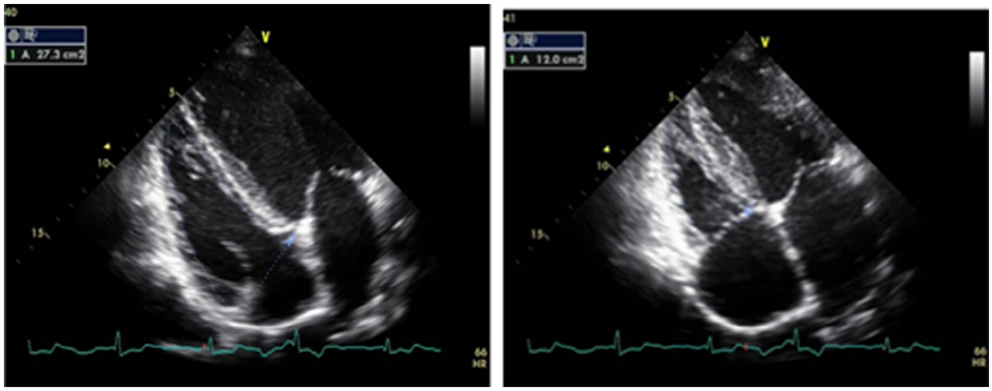

Fig. 1. Right ventricular fractional area change (RVFAC).

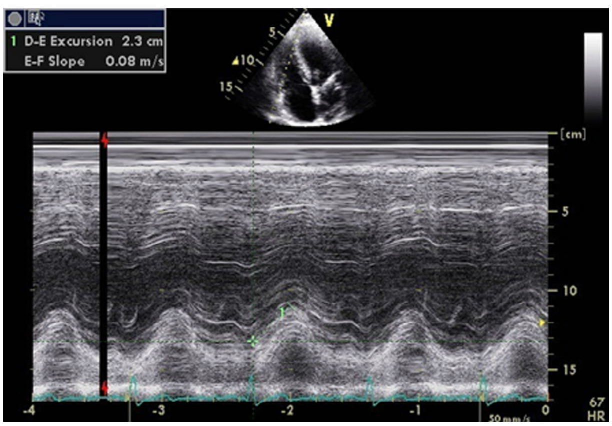

Fig. 2. Measurement of tricuspid annular plane systolic excursion (TAPSE) by M-mode in standard apical 4-chamber view.

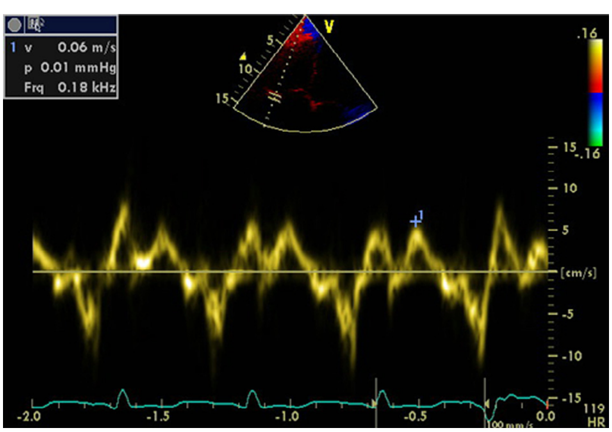

Fig. 3. Tricuspid annular tissue Doppler imaging. Peak myocardial systolic velocity S′ wave which was diminished in this patient (6cm/s).

four-chamber view: the TDI cursor was placed at lateral tricuspid annulus in such a way that the annulus moved along the sample volume line to estimate the following:

(a) **Systolic Velocity at the lateral tricuspid annulus (S′):** Velocity of the major positive wave recorded with the movement of the annulus toward the cardiac apex during systole in three cardiac beats was measured and the mean value was calculated in cm/s (Fig. 3).

(b) **Ejection time (ET):** In the TDI images, S′ duration was measured as the ejection time (ET), calculated from the beginning to the end of the S′ wave.

(c) **The tricuspid (valve) closure opening time (TCO):** It encompasses isovolumic contraction time, ejection time (ET), and isovolumic relaxation time. It is measured as time interval from end of A′ till the beginning of next E′ (Fig. 4).

(d) Right ventricular myocardial performance index (MPI): was calculated as; (TCO–ET)/ET.[3]

2.3. Statistical analysis

All demographic, clinical, and technical data were collected and tabulated using the "Data Collection Form" and entered into a computerized database. Statistical analyses were performed using SPSS for Windows (version 11.0, SPSS Inc, Chicago, Illinois). Continuous variables were presented as mean ± 1 standard deviation (SD) and categorical variables as numbers and percentages. Comparisons between the groups were made by student t test for continuous variables and Fisher Exact test for categorical variables. Bivariate correlations were analyzed by Spearman's test as indicated, A p-value of less than 0.05 considered of statistical significance and a p – value less than or equal 0.01 was considered highly significant.

3. Results

The study was carried on 100 chronic left sided heart failure patients with mean EF of 30.75% (EF ranged from 16 to 40%).

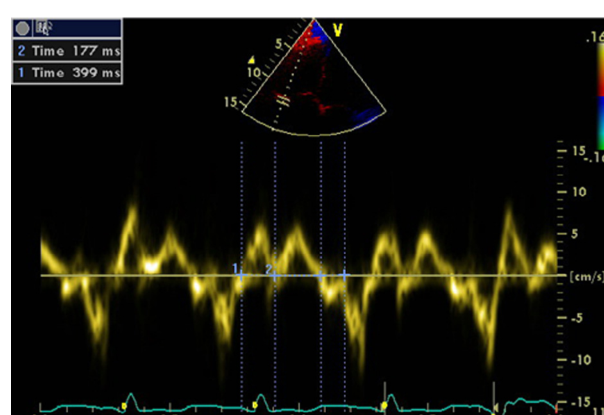

Fig. 4. in the same patient, measurement of tricuspid closure opening time (TCO) 1 & Ejection time (ET) 2. Then MPI calculated as TCO-ET/ET = 1.2.

3.1. Demographic and clinical data of the studied patients

Mean Age was 49.82 ± 8.90 Yrs, 83 patients (83%) were males, 58 patients (58%) were smokers, 54 patients (54%) were diabetics, 56 patients (56%) were hypertensives, while 66 patients (66%) were dyslipidemic.

Regarding the NYHA Functional Class: 58 patients (58%) presented by NYHA Class II, 33 patients (33%) presented by NYHA Class III, and only 9 patients (9%) were in NYHA Class IV. 33 patients (33%) had LL edema, while Elevated JVP was detected in 32 patients (32%).

3.2. Echocardiographic parameters

The mean values of different echocardiographic left & right ventricular parameters are shown in Table 1.

Right ventricle was dilated at the basal level (>42 mm) in 36 patients (36%) & at the mid cavity level (>35 mm) in 23 patients (23%). Longitudinal RV diameter was enlarged in (>86 mm) in 20 patients (20%).

Tricuspid regurgitation was reported in 69 patients, the mean value of the estimated RVSP in them was 39 ± 16 mmHg. Pulmonary hypertension defined as RVSP > 35 mmHg was detected in 44 patients of this group.

The mean value of tissue Doppler derived MPI was 0.63 and it was found to be abnormal (>0.55) in 67patients indicating RV dysfunction in this group of patients. S′ velocity was found to be reduced (<10 cm/s) in 60 patients. FAC was found to be impaired (<35%) in 35 patients & TAPSE was reduced (<16 mm) in 30 patients.

Patients were divided into 2 groups according to presence of impaired right ventricular systolic function defined as presence of these three parameters together FAC < 35%, TAPSE < 16 mm and S′ wave velocity < 10 cm/s.[3]

Group A: included 64 patients with normal right ventricular systolic function parameters.
Group B: included 36 patients with impaired all right ventricular systolic function parameters.

Both demographic and clinical data of patients in group A and group B are shown in Table 2.

Table 1
LV & RV echocardiographic parameters of the studied patients.

Parameter	Mean ± SD
LV parameters	
LVEDD (mm)	71.1 ± 9.6
LVESD (mm)	59.7 ± 9.0
IVS (mm)	9.3 ± 1.6
PWT (mm)	9.1 ± 1.5
LVEDV (ml)	203.47 ± 79.35
LVESV (ml)	142.28 ± 57.81
EF (%)	30.75 ± 7.0
RV parameters	
RV basal diameter (mm)	40.5 ± 7.5
RV mid diameter (mm)	33.9 ± 5.6
RV longitudinal diameter (mm)	78.8 ± 9.9
FAC (%)	36.1 ± 9.18
TAPSE (mm)	17.4 ± 3.1
S′ velocity (cm/s)	8.36 ± 2.2
Tei index	0.63 ± 0.14
TR (no. %)	69 (69%)
Mild	46 (46%)
Moderate	18 (18%)
Severe	5 (5%)
RVSP (mmHg)	39 ± 16

Table 2
Demographic and clinical data in both groups.

	Group A (Normal RV systolic function) (n = 64)	Group B (Impaired RV systolic function) (n = 36)	P value
Age (years) (Mean ± SD)	49.92 ± 7.95	49.64 ± 10.50	NS
Gender			
Male (n, %)	53 (82.8%)	30 (83.3%)	NS
Female (n, %)	11 (17.2%)	6 (16.7%)	
Hypertension (n, %)	37 (57.8%)	19 (52.8%)	NS
Diabetes (n, %)	35 (54.7%)	19 (52.8%)	NS
Dyslipidemia (n, %)	45 (70.3%)	21 (58.3%)	NS
Smoking (n, %)	42 (65.6%)	26 (72.4%)	NS
LL oedema (n, %)	18 (28.1%)	15 (41.7%)	NS
Elevated JVP	12 (18.75%)	20 (55.56%)	0.001*
NYHA Classification			
Class I	0 (0.0%)	0 (0.0%)	NS
Class II	41 (64.1%)	17 (47.2%)	
Class III	19 (29.7%)	14 (38.9%)	
Class IV	4 (6.2%)	5 (13.9%)	

* Denotes highly significant difference.

No significant difference was found between the two groups regarding age, sex or different risk factors. Group B patients were more symptomatic; had worse NYHA class (52.8% of them had NYHA III or IV versus 35.9% in group A), higher incidence of lower limb edema however these differences were statistically non significant. Group (B) had a significantly higher incidence of congested neck veins (Table 2).

Conventional echocardiographic data analysis of the left ventricle revealed; No statistically significant difference between both groups regarding LV end-diastolic volumes and dimensions. Group B had significantly larger end-systolic dimensions and significantly lower LVEF. Group B also had significantly higher incidence of restrictive LV diastolic dysfunction (grade III) (Table 3).

3.3. Regarding RV parameters by echocardiography Table 4

Classification of patients into group A and Group B was done according to FAC, TAPSE and S′ velocity. The mean ± SD of these variables were 41.86 ± 5.05 versus 26.03 ± 5.26%, 19.2 ± 2.0 versus 14.1 ± 1.8 mm and 9.53 ± 1.79 versus 6.27 ± 1.00 cm/s in groups A and B, respectively.

Group (B) showed significantly larger RV dimensions at different levels, significantly higher mean value of RVSP and significantly worse degree of TR, significantly higher MPI (Tei index).

Table 3
Comparison between the two studied groups regarding left ventricular echocardiographic findings.

	Group A (Normal RV systolic function) (n = 64)	Group B (Impaired RV systolic function) (n = 36)	P value
EDD (mm) (Mean ± SD)	69.8 ± 9.1	73.4 ± 10.0	0.069
ESD (mm) ((Mean ± SD)	57.9 ± 8.1	62.9 ± 9.7	0.006*
PWT (mm) (Mean ± SD)	9.0 ± 1.7	9.1 ± 1.2	0.838
IVS (mm) (Mean ± SD)	9.3 ± 1.6	9.3 ± 1.5	0.949
EDV (ml) (Mean ± SD)	197.61 ± 73.8	213.89 ± 88.51	0.327
ESV (ml) (Mean ± SD)	134.92 ± 56.2	155.36 ± 59.1	0.090
EF (%)	32.19 ± 6.11	28.19 ± 7.834	0.006*
Grade of LV diastolic dysfunction;			0.035*
Grade I (n, %)	16 (25.0%)	2 (5.6%)	
Grade II (n, %)	30 (46.9%)	18 (50.0%)	
Grade III (n, %)	18 (28.1%)	16 (44.4%)	

* Denotes highly significant difference.

Table 4
Comparison between the two group regarding right ventricular echocardiographic parameters:

	Group A (Normal RV systolic function) (n = 64)	Group B (Impaired RV systolic function) (n = 36)	P value
RV basal diameter (mm) (mean ± SD)	38.3 ± 7.2	44.3 ± 6.4	0.000*
RV mid diameter (mm) (mean ± SD)	32.2 ± 4.9	36.9 ± 5.7	0.000*
RV long. diameter (mm) (mean ± SD)	77.0 ± 9.2	82.1 ± 10.4	0.014*
MPI (Tei index) (mean ± SD)	0.60 ± 0.14	0.68 ± 0.13	0.006*
RVSP (mmHg) (Mean ± SD)	36.02 ± 16.29	44.56 ± 14.09	0.010*
Grade of TR;			0.000*
No TR (n, %)	27 (42.2%)	4 (11.1%)	
Mild (n, %)	30 (46.9%)	16 (44.4%)	
Moderate (n, %)	7 (10.9%)	11 (30.6%)	
Severe (n, %)	0 (0.0%)	5 (13.9%)	

* Denotes highly significant difference.

4. Discussion

Right ventricular (RV) function is an important determinant of the clinical status in chronic HF patients. The relation between RV dysfunction and poor exercise capacity; and between preserved RV functions and good exercise capacity as well as better hemodynamics even in severely reduced left ventricular ejection fraction (LVEF) are well established.[15]

Multiple mechanisms affect RV contractility in cases of in idiopathic DCM like increased right ventricular after load with pulmonary hypertension, RV is usually also affected by the cardiomyopathic process, ventricular interdependence caused by septal dysfunction, and myocardial ischemia due to reduced coronary perfusion. RV systolic dysfunction is thought to be a common final pathway in HF and so carries a high risk of poor prognosis.[16]

Tricuspid regurgitation (TR) and signs of systemic venous congestion, like elevated jugular venous pressures, predict higher mortality in heart failure patients.[17] Elevated right atrial pressure is associated with hepatic and renal impairment, leading to malnutrition and the cardiorenal syndrome.[18]

Risk stratification in DCM is important because of the associated morbidity and mortality as well as sudden cardiac death in left sided heart failure patients.[19] Although current stratification is mainly centered on the degree of adverse LV remodeling, there is increasing identification of the importance of RV systolic dysfunction on both morbidity and mortality.[20]

Cardiovascular magnetic resonance (CMR) is recommended by the guidelines as the gold standard technique for RV assessment, yet it is not readily available which is considered a major limitation.[21]

Echocardiography is a non-invasive, cheap and available method of RV function assessment. That is why transthoracic echocardiography is typically the imaging technique of choice for RV evaulation.[20] Yet accurate assessment of RV morphology and function is not easy mainly because of the complexity of RV anatomy.

So the aim of the present study was to review the echocardiographic alterations of right ventricular dimensions & function associated with chronic heart failure, and to predict the prevalence of right ventricular systolic dysfunction in patients with chronic heart failure, based on echocardiographic parameters.

In the current study RV was dilated at the basal level (>42 mm) in 36% of the patients & at the mid cavity level (>35 mm) in 23% of the studied patients. Longitudinal RV diameter was enlarged in (>86 mm) in 20% of the patients. We searched across different data bases to compare our data regarding morphological changes of RV in patients with DCM and to our knowledge these data was not assessed before.

The studied patients were divided into 2 groups according to presence of impaired right ventricular systolic function defined as FAC < 35%, TAPSE < 16 mm and S′ wave velocity < 10 cm/s.[3]

To differentiate normal from abnormal RV function it is better to combine more than one parameter, especially when RV dysfunction is clinically suspected and or when the patient is suffering from a condition that might influence the right ventricular function.[22]

In the current study, RV systolic dysfunction was relatively common in patients with left sided heart failure as 36% of the studied patients had RV systolic dysfunction and **in concordance to our study, *Pennel in 2010***[4] demonstrated that prevalence of RV systolic dysfunction was 34% in his studied patients.

In a study carried by ***Gulati et al. in 2013***,[23] who studied 250 consecutive DCM patients with the use of cardiac MRI. RV systolic dysfunction, defined by RV ejection fraction ≤ 45%, was present in 86 (34%) patients and it represents an independent risk factor for worse outcome. After adjustment for well known risk factors for worse outcome in LV failure like LV parameters and NYHA functional class on multivariable analysis, patients with RV systolic dysfunction had a 4-fold increase in all cause mortality or cardiac transplantation. Absence of systolic RV dysfunction was an independent predictor of transplant-free survival and better HF outcomes.

In discordance to the current study, ***Meluzin et al., in 2003***[24] who studied 44 patients with heart failure to verify the importance of TDI of tricuspid annular motion in assessment of RV function. 70% of patients had RV systolic function impairment. The difference in results might be explained by different methods of assessment of RV function as they assessed RV function by TDI only and also those patients were candidates for heart transplantation which means that they had end stage heart failure.

In the current study, no age or sex differences could be detected between patients with normal right ventricular systolic function parameters (group A) & patients with impaired right ventricular systolic function parameters (group B). This goes in concordance with, ***Kjaergaard et al., in 2009***[25] who studied the relation of TAPSE to LV function in 634 patients with symptomatic heart failure, they found that TAPSE was not related to age and sex of patients.

Also, ***Pennel in 2010***[4] who measured RV systolic function in 250 consecutive DCM patients by cardiac MRI, he found that age and sex were not related to presence or absence of RV systolic dysfunction. Similarly In the study carried by ***Gulati et al., in 2013,***[23] who studied 250 DCM patients with the use of cardiac MRI, they concluded that there is no significant correlation between age or sex and presence or absence of RV systolic dysfunction.

In the current study, patients with RV systolic dysfunction had significantly higher incidence of elevated JVP and non significantly higher incidence of lower limb edema than those without RV systolic dysfunction. In concordance to that, ***Ravi et al., in 2011***[26] reported that elevated JVP and presence of lower limb edema was found in most of the patients with RV systolic dysfunction.

In the current study, patients with RV systolic dysfunction were more symptomatic and they had worse NYHA class (52.8% of them had NYHA III or IV versus 35.9% in group A). In the study carried by ***Gulati et al., in 2013***[23] they stated that, patients with RV systolic dysfunction had worse NYHA class compared to patients without RV systolic dysfunction.

In the current study, patients with RV systolic dysfunction had significantly larger end-systolic dimensions and significantly lower LVEF, yet EDD, ESV and EDV were non significantly larger in them. This goes in concordance with ***Chrysohoou et al., 2011***,[27] ***Pennel 2010***[4] ***and Ravi et al., 2011***[26] who reported a proportionate relation between larger RV size and worse RV function with lower LV EF, this can be explained by the septal contribution to RV contraction.

Also in the study carried by ***Gulati et al., in 2013***[23], worse RV systolic function was associated with larger ventricular volumes and lower LV function. They observed a positive correlation between RVEF and LVEF measurements with the use of cardiac MRI *($r = 0.58$; $P < 0.001$)*.

In the present study, higher grades of LV diastolic dysfunction were more common in patients with RV systolic dysfunction, they had significantly higher incidence of restrictive LV diastolic dysfunction (grade III).

In concordance to the current study, ***Kjaergaard et al., in 2009***[25] found that less TAPSE values was associated with higher grades of LV diastolic dysfunction.

This goes with a study carried by ***Venner et al. in 2016***[28]; who studied 136 patients with idiopathic dilated cardiomyopathy [LV EF $\leq$ 45%], divided into two groups with or without RV dysfunction [TAPSE < 15 mm], they found that E deceleration time was significantly shorter in patients with RV systolic dysfunction (119.89 ± 34.42 ms vs 166.15 ± 61.81 ms, $P < 0.001$), and that E-wave deceleration time $\leq$ 145 ms is an independent predictor of RV dysfunction. They also highlighted the impact of RV function on outcome in patients with LV systolic dysfunction, regardless the degree of LV EF impairment.

Ghio et al., in 2013[29] also highlighted the correlation between restrictive pattern of LV diastolic function and TAPSE values < 14 mm, together with four times increased risk of cardiovascular events in these group of patients.

5. Conclusion

- The occurrence of right ventricular systolic dysfunction in left ventricular failure is common [Approaching 40%] and is independent of age and sex, and is proportionate to EF impairment and restrictive LV diastolic dysfunction.
- Patients with right ventricular systolic dysfunction defined as FAC < 35%, TAPSE < 16 mm and S′ wave velocity < 10 cm/s together, showed significantly larger RV dimensions at different levels, significantly higher mean value of RVSP, significantly worse degree of TR and significantly higher MPI (Tei index).

5.1. Limitations

- Small sample size from a single centre.
- No follow-up data were available to verify the influence of RV systolic dysfunction on survival.
- We did not have data about coronary anatomy as we excluded presence of coronary heart disease by history and absence of resting segmental wall motion abnormalities on echocardiography.
- RVSP was not assessed invasively we only depended on CWD estimation by using TR Jet, which could not be detected in all patients.

Conflict of interest

The authors declare that there is no conflict of interest.

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