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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.

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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

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