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Right ventricular systolic and diastolic function in heart failure with preserved ejection fraction

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SOUHRN

Kontext: Srdeční selhání (heart failure, HF) se zachovanou ejekční frakcí (EF) představuje v poslední době závažný zdravotní problém. Je prokázáno, že je významnou příčinou kardiovaskulární morbidity a mortality. Při srdečním selhání se sníženou EF často dochází k dysfunkci pravé komory jako postižení spojenému s poruchou funkční kapacity a nepříznivou prognózou.
Cíl: Cílem této práce bylo hodnotit systolickou a diastolickou funkci pravé komory u pacientů se srdečním selháním a zachovanou ejekční frakcí levé komory (LVEF).
Metody: Do studie bylo zařazeno 50 pacientů se srdečním selháním se zachovanou ejekční frakcí (heart failure with preserved ejection fraction, HFpEF), „diastolickým srdečním selháním" (LVEF ≥ 50 %) a 50 zdravých jedinců srovnatelného pohlaví a věku. U všech účastníků studie se zaznamenával krevní tlak a bylo provedeno vyšetření krve i úplné echokardiografické vyšetření pravé komory (right ventricle, RV) a klasické 2D echokardiografické vyšetření levé komory (left ventricle, LV).
Výsledky: Při použití kritérií frakční změna plochy pravé komory (right ventricular fractional area change, RV FAC), maximální vychýlení trikuspidálního prstence v systole (tricuspid annular plane systolic excursion, TAPSE), vrcholová systolická rychlost (St) trikuspidálního prstence (peak systolic tricuspid annular tissue velocity, S') a dopplerovský index výkonnosti myokardu (tissue Doppler myocardial performance index, TD MPI) byla nalezena prevalence systolické dysfunkce pravé komory ve výši 30, resp. 34, 32 a 36 %. Při hodnocení pulsní a tkáňovou dopplerovskou echokardiografií s kritérii trikuspidálního poměru E/A (T E/A), trikuspidálního decelaračního času (tricuspid deceleration time, TDT) a trikuspidálního poměru E/E` (T E/E') činila prevalence diastolické dysfunkce pravé komory 64, resp. 32 a 48 %.
Závěr: Systolická a diastolická dysfunkce pravé komory nebyla u pacientů se srdečním selháním se zachovanou ejekční frakcí nijak výjimečná.

ABSTRACT

Background: Heart failure (HF) with preserved ejection fraction (EF) has recently become an important health problem. It has been established as a major cause of cardiovascular morbidity and mortality. In heart failure with reduced ejection fraction right ventricular dysfunction is common and is associated with impaired functional capacity and poor prognosis.
Aim: The aim of this work was to study the right ventricular systolic and diastolic functions in patients with heart failure and preserved left ventricular ejection fraction.
Methods: We included fifty patients with heart failure with preserved ejection fraction (HFpEF), "diastolic heart failure" (LVEF ≥ 50%) and fifty normal subjects, comparable for sex and age. All subjects underwent blood pressure measurement, laboratory blood tests, complete right ventricle (RV) and conventional left ventricle (LV) 2D echocardiographic study.
Results: The prevalence of right ventricular (RV) systolic dysfunction in patients with heart failure was 30, 34, 32 and 36%, by using right ventricular fractional area change (RV FAC), tricuspid annular plane systolic excursion (TAPSE), peak systolic tricuspid annular tissue velocity (S') and tissue Doppler myocardial performance index (TD MPI) criteria, respectively. The prevalence of right ventricular diastolic dysfunction studied by pulsed and tissue Doppler echocardiography was 64, 32, and 48%, using tricuspid E/A ratio (T E/A), tricuspid deceleration time (TDT) and tricuspid E/E` ratio (T E/E') criteria, respectively.
Conclusion: The prevalence of right ventricular systolic and diastolic dysfunctions was not uncommon in patients with heart failure with preserved ejection fraction.

Keywords:
Echocardiography
Heart failure
Preserved ejection fraction
Right ventricle

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Introduction

Heart failure (HF) with preserved ejection fraction (EF), "diastolic heart failure", has recently become an important health problem. It has been established as a major cause of cardiovascular morbidity and mortality.[1,2] The mortality of this clinical syndrome is similar to that of HF with reduced left ventricular ejection fraction, previously called systolic HF.[3]

Diastolic heart failure is defined as a condition caused by increased resistance to the filling of one or both ventricles; this leads to symptoms of congestion from the inappropriate upward shift of the diastolic pressure-volume relation.[4] Vasan and Levy[5] used 2 types of criteria to classify diastolic HF diagnosis into 3 categories: definitive, probable, and possible (Table 1).

Heart failure may be associated with a wide spectrum of LV functional abnormalities, which may range from patients with normal LV size and preserved EF to those with severe dilatation and/or markedly reduced EF. In most patients, abnormalities of systolic and diastolic dysfunction coexist, irrespective of EF. Ejection fraction is considered important in a classification of patients with HF because of differing patient demographics, comorbid conditions, prognosis, and response to therapies (Table 2).[6]

Pathophysiology of diastolic heart failure

Diastolic function is determined by the passive elastic properties of the left ventricle and by the process of active relaxation. The effects of impaired active myocardial relaxation can further stiffen the ventricle. As a result, the curve for left ventricular diastolic pressure in relation to volume is shifted upward and to the left (Fig. 1) and the diastolic pressure is elevated.[8]

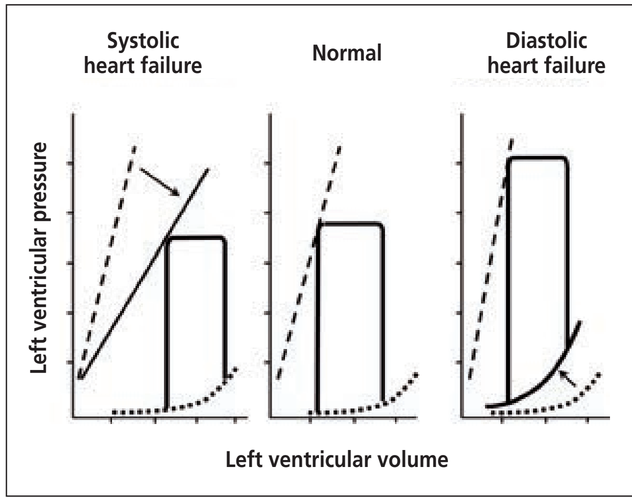


Fig. 1 – Schematic left ventricle pressure-volume relationship through one cardiac cycle in systolic heart failure (left), a normal control (center), and diastolic heart failure (right). The dominant functional abnormality in systolic heart failure is a decrease in LV contractility, as evidenced by a decrease in the slope of the end--systolic pressure-volume relationship. However, the predominant functional abnormality in diastolic heart failure is an increase in diastolic stiffness, as evidenced by an upward and leftward shift of the diastolic pressure-volume relationship.[9]

Table 1 – Criteria for the diagnosis of diastolic heart failure[5]

Definitive diagnosis	Probable diagnosis	Possible diagnosis
Definitive clinical evidence of heart failure, and	Definitive clinical evidence of heart failure, and	Definitive clinical evidence of heart failure, and
Normal left ventricular systolic function with ejection fraction (EF) >50% determined in the 72 hours following clinical decompensation and	Normal left ventricular systolic function with ejection fraction >50% determined in the 72 hours following clinical decompensation	Normal left ventricular systolic function with ejection fraction >50% determined outside of the 72 hours following clinical decompensation
Objective evidence of diastolic dysfunction in the hemodynamic study (increase in diastolic pressure with normal or reduced diastolic volume)		

Table 2 – Definitions of HFrEF and HFpEF[7]

Classification	EF (%)	Description
I. Heart failure with reduced ejection fraction (HFrEF)	≤40	Also referred to as systolic HF. Randomized controlled trials have mainly enrolled patients with HFrEF, and it is only in these patients that efficacious therapies have been demonstrated to date.
II. Heart failure with preserved ejection fraction (HFpEF)	≥50	Also referred to as diastolic HF. Several different criteria have been used to further define HFpEF. The diagnosis of HFpEF is challenging because it is largely one of excluding other potential noncardiac causes of symptoms suggestive of HF. To date, efficacious therapies have not been identified.
a. HFpEF, borderline	41 to 49	These patients fall into a borderline or intermediate group. Their characteristics, treatment patterns, and outcomes appear similar to those of patients with HFpEF.
b. HFpEF, improved	>40	It has been recognized that a subset of patients with HFpEF previously had HFrEF. These patients with improvement or recovery in EF may be clinically distinct from those with persistently preserved or reduced EF. Further research is needed to better characterize these patients.

EF – ejection fraction; HF – heart failure; HFpEF – heart failure with preserved ejection fraction; HFrEF – heart failure with reduced ejection fraction.

Classification

- I. Systemic
  - Hypertension
  - Diabetes mellitus
  - Advanced age
  - Renal insufficiency
  - Thyrotoxicosis
- II. Myocardial
  - Coronary artery disease
  - Valvular disease
  - Aortic stenosis
  - Cardiomyopathies
  - Hypertrophic obstructive
  - Restrictive
  - Idiopathic
- III. Infiltrative
  - Hemochromatosis
  - Sarcoidosis
  - Idiopathic
- IV. Pericardial
  - Pericardial effusion
  - Constrictive pericarditis

Fig. 2 – Causes of diastolic heart failure.[12]

Prevalence and etiology

It was found that 40 percent of patients with heart failure have preserved systolic function.[10] The incidence of diastolic heart failure increases with age and it is more common in older women. Hypertension and cardiac ischemia are the most common causes of diastolic heart failure (Fig. 2).[11]

In heart failure with reduced ejection fraction (HFrEF), right ventricular dysfunction (RVD) is common[13] and is associated with impaired functional capacity and poor prognosis.[14] In HFrEF, ischemic or myopathic processes may directly involve the right ventricle (RV) and lead to RVD. Isolated insults to the left ventricle (LV) can lead to pulmonary hypertension (PH) and neurohumoral and cytokine activation. The resulting RV pressure overload, inflammation and altered RV myocardial gene expression promote RVD in the absence of primary RV myocardial injury.[15]

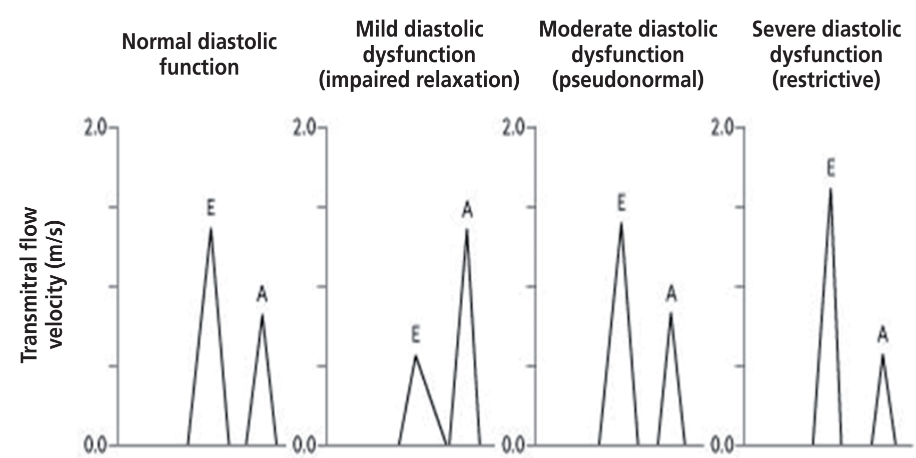
The role of transthoracic echocardiography

Since the documentation of a normal or near-normal LV ejection fraction it is necessary for the diagnosis of heart failure with preserved ejection fraction (HFpEF), so echocardiographic evaluation is essential for proper diagnosis.

Doppler echocardiography

In normal sinus rhythm, diastolic flow from the left atrium to the left ventricle across the mitral valve has two components – the E wave, which reflects early diastolic filling, and the A wave, in late diastole, which reflects atrial contraction. Alterations in the pattern of these velocities give insight into left ventricular diastolic function and into prognosis (Fig. 3).[16]

The abnormal relaxation pattern represented reduced velocity of early filling (E wave), an increase in the velocity associated with atrial contraction (A wave), and a ratio of E to A that is lower than normal. In more advanced heart disease, when left atrial pressure has raised the E-wave velocity and E/A ratio is similar to that in normal subjects (the pseudonormal pattern). In advanced disease, abnormalities in left ventricular compliance may supervene (called the restrictive pattern because it was originally described in patients with restrictive cardiomyopathy).[1,16]



Left ventricular relaxation	Normal	Impaired	Impaired	Impaired
Left ventricular compliance	Normal	Normal to ↓	↓↓	↓↓↓
Atrial pressure	Normal	Normal to ↑	↑↑	↑↑↑

Fig. 3 – Patterns of LV diastolic filling as shown by standard Doppler echocardiography.[16]

Treatment of diastolic heart failure

Although the conclusive data on specific therapies for diastolic heart failure are lacking, the American College of Cardiology and the American Heart Association joint guidelines recommend that physicians address blood pressure control, heart rate control, central blood volume reduction, and alleviation of myocardial ischemia when treating patients with diastolic heart failure (Table 3).[17]

Aim of work

The current study aimed to comprehensively assess right heart function in HFpEF.

Patients and methods

The case-control study conducted on fifty patients with preserved LV ejection fraction "diastolic" heart failure selected from the outpatient clinic at Cairo University Hospital. Fifty healthy age and sex matched subjects were recruited as controls. Patients with atrial fibrillation, atrial flutter, bundle branch block, congenital heart diseases, valvular heart diseases or reduced ejection fraction were excluded from the study. The study protocol was approved by the local Ethics Committee.

All patients were subjected to detailed medical history and clinical examination. Diabetes mellitus was defined as fasting plasma glucose ≥126 mg/dl and/or random plasma glucose ≥200 mg/dl and/or self-reported diabetes.[18] Hypertension was defined according to the recently released American College of Cardiology (ACC)/American Heart Association (AHA) hypertension guidelines.[19]

Echocardiography study

Transthoracic echocardiography was performed in all patients using General Electric VIVID 7 (GE HealthMedical, Horten, Norway). Images were obtained using a 2.5 MH_z transducer. Conventional two-dimensional echocardiography including M-mode was performed on all patients according to the American Society of Echocardiography (ASE) recommendations.[20]

The left ventricle end-systolic (LVESD) and end-diastolic diameters (LVEDD), left ventricle free wall posterior wall thickness (PWT), and interventricular septum thickness (IVS), left ventricular ejection fraction (LVEF) and chambers quantification were measured according to the recommendations of the American Society of Echocardiography.[20]

Left ventricle mass was calculated using the Devereux formula.[21] The LV mass index (LVMI, g/m^2) was defined as LV mass divided by body surface area (m^2). The reference ranges used to define left ventricle hypertrophy was left ventricle mass index above 115 and 95 g/m^2 for males and females, respectively.[22]

The analysis of trans-mitral inflow velocities was obtained by the pulsed Doppler in the apical four chamber view with the sample volume placed at the mitral valve leaflet tips. Measurements included the trans-mitral early diastolic peak flow velocity (E), late diastolic flow velocity (A), their ratio (M E/A), and deceleration time (E-DT).[23]

Right ventricular length and diastolic diameters were measured at the base- and mid-ventricle perpendicularly to the septum.[24] Tricuspid annular plane systolic excursion (TAPSE), pulsed Doppler S wave (S′) and fractional area change (FAC) have, by far, the most available reference data to support their use in the evaluation of the right ventricle systolic function.[20] Tricuspid annular plane systolic excursion (TAPSE) represents the systolic movement of the base of the RV free wall. TAPSE is a method to measure the distance of systolic excursion of the RV annular segment along its longitudinal plane, from a standard apical 4-chamber window. TAPSE <17 mm is highly suggestive of RV systolic dysfunction (Fig. 4).[25]

Right ventricle 2D fraction area change (FAC) provides an estimate of global RV systolic function. It is important to ensure that the entire right ventricle is contained in the imaging sector including the apex and the free wall during both systole and diastole. RV FAC <35% indicates RV systolic dysfunction (Fig. 5).[20]

Tissue Doppler imaging was used to obtain RV myocardial velocities in the apical 4-chamber view with a 2 mm

Table 3 – Recommendations for treatment of HFpEF[7]

Recommendations	COR	LOE
Systolic and diastolic blood pressure should be controlled according to published clinical practice guidelines	I	B
Diuretics should be used for relief of symptoms due to volume overload	I	C
Coronary revascularization for patients with CAD in whom angina or demonstrable myocardial ischemia is present despite GDMT	IIa	C
Management of AF according to published clinical practice guidelines for HFpEF to improve symptomatic HF	IIa	C
Use of beta-blocking agents, ACE inhibitors, and ARBs for hypertension in HFpEF	IIa	C
ARBs might be considered to decrease hospitalizations in HFpEF	IIb	B
Nutritional supplementation is not recommended in HFpEF	III: No benefit	C

ACE – angiotensin-converting enzyme; AF – atrial fibrillation; ARB – angiotensin-receptor blocker; CAD – coronary artery disease; COR – class of recommendation; GDMT – guideline-directed medical therapy; HF – heart failure; HFpEF – heart failure with preserved ejection fraction; LOE – level of evidence.[7]

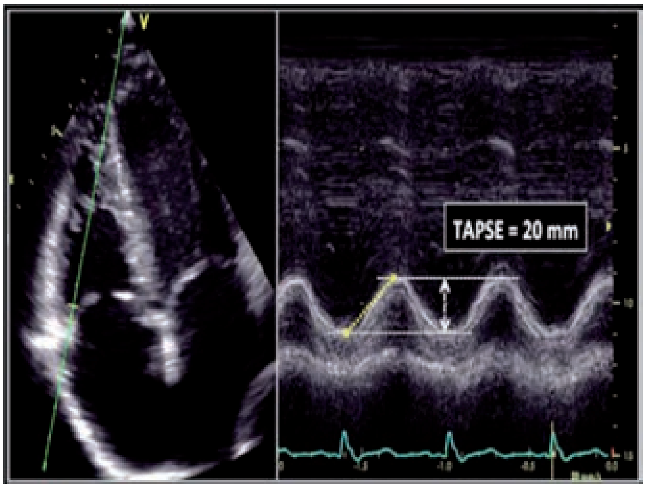


Fig. 4 – Measurement of tricuspid annular plane systolic excursion (TAPSE).[23]

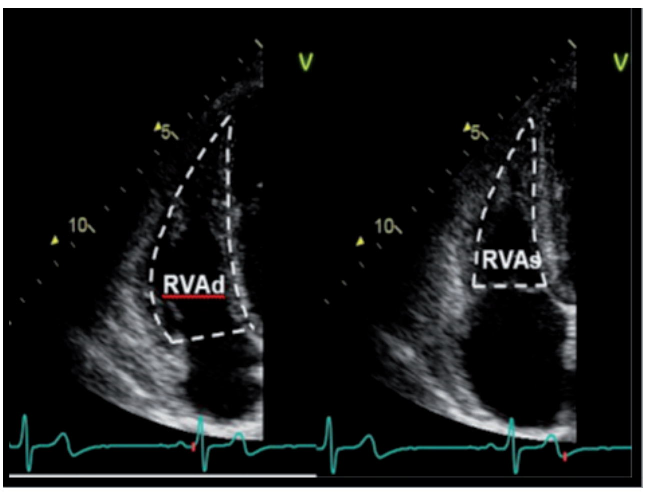


Fig. 5 – Right ventricle 2D fraction area change. Manual tracing of the right ventricle endocardial border from the lateral tricuspid annulus along the free wall to the apex and back along the interventricular septum to the medial tricuspid valve annulus. Measurements done at end-diastole and end-systole.[26]

sample volume placed at the lateral segment of tricuspid annulus during early diastole (E`) and systole (S`).[20]

The parameters necessary for the calculation of the MPI or Tei index were obtained by the tissue Doppler in the apical 4-chamber view.[20]

The isovolumic contraction time (IVCT) and isovolumic relaxation time (IVRT) were measured from the end of the late diastolic (A`) wave to the onset of the systolic wave (S`), and from the end of the systolic wave (S`) to the onset of the early (E`) wave, respectively.

The ejection time (ET) was defined as the duration of (S`) wave. MPI for the RV was calculated according to the formula: MPI = (IVCT + IVRT)/ET.

RIMP > 0.54 by Doppler tissue imaging indicate RV dysfunction (Fig. 6).[20]

RV diastolic function: E/A ratio, E/E` ratio and deceleration time (DT): Tricuspid flow velocities were achieved by the standard pulsed Doppler technique in the apical 4-chamber view placing the sample volume at the tips of the tricuspid leaflets. The following parameters were determined: early diastolic peak flow velocity (E), late diastolic flow velocity (A), their ratio (E/A), and deceleration time (DT).

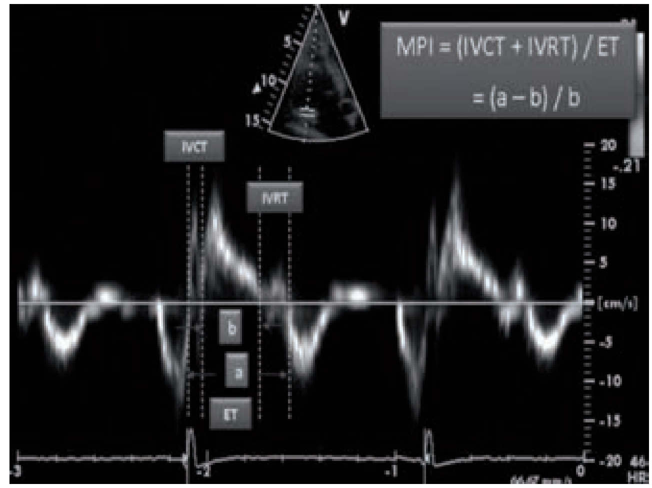


Fig. 6 – Measurement of myocardial performance index (MPI) using tissue Doppler imaging.[24] ET – ejection time; IVCT – isovolumic contraction time; IVRT – isovolumic relaxation time.

Abnormal RV diastolic function was present if tricuspid E/A ratio <0.8 or >2.0, E/E′ ratio > 6 and E wave deceleration time (<119 or >242 ms).[20]

Statistical analysis

Data were analyzed with the Statistical Package for the Social Sciences (SPSS for Windows software package version 21.0; SPSS, Inc., Chicago, IL, USA). Continuous variables were presented as mean ± standard deviation (SD) and compared by using the t-test for two independent samples as they showed a normal distribution. Median and range and the Mann-Whitney U-test were used for variables that showed non normal distribution. Categorical variables were presented as frequency and percentage. Differences in proportions were compared by using the Chi-square test. Correlations were sought using the Spearman and Pearson correlation analyses where appropriate to determine correlation between different demographic, clinical, and echocardiographic parameters; a value < 0.05 was considered statistically significant.

Results

The study population included 100 individuals divided into two groups. Fifty patients were diagnosed as diastolic heart failure (DHF) and the other 50 were healthy subjects and were included as a control group. There was an important statistical difference in the systolic and diastolic blood pressure measurements between the two groups (Table 4).

We found that 84% (n = 42) of patients with DHF were hypertensive, 32% (n = 16) were diabetics, 38% (n = 19) had coronary artery disease (CAD) (documented by regional wall motion abnormalities, ECG changes of myocardial ischemia or by history of revascularization) and only 2 patients with hypertrophic cardiomyopathy (HCM) diagnosed by identification of hypertrophied LV of wall thickness typically ≥15 mm in adults without another underlying cause.

In DHF group, the main presenting symptom was dyspnea, and the most common presenting sign was bilateral pitting lower limb edema and S4 over the apex. Clinical presentation was ranging from NYHA class I to NYHA class IV (Fig. 7).

Echocardiography parameters

The ratio between trans-mitral early diastolic flow (E) and late diastolic mitral flow (A) was significantly decreased among the DHF patients **(1.0±0.4 vs. 1.2±0.1, *p* = 0.002)**. EF was significantly decreased **(58.2±4.3 vs. 65.4±3.8%, *p* < 0.001)** among DHF patients (Table 5).

RV basal, mid and longitudinal diameters were increased in DHF group compared to the control group **(4.0 vs. 3.2 cm, *p* <0.001), (3.3 vs. 2.6 cm, *p* <0.001) and (7.6 vs. 6.7 cm, *p* <0.001),** respectively.

The prevalence of RV systolic dysfunction in DHF patients was 34, 30, 32, and 36%, by using tricuspid annular plane systolic excursion (TAPSE), RV fraction area change (RV FAC), peak systolic tricuspid annular tissue velocity (RV S'), and tissue Doppler myocardial performance index (TD MPI) criteria, respectively.

The prevalence of RV diastolic dysfunction in DHF patients was 64, 32, and 48%, by using tricuspid E/A ratio (T E/A), tricuspid deceleration time (TDT) and tricuspid E/E` ratio (T E/E') criteria, respectively (Table 6).

Using Pearson Correlation Coefficient analysis SBP had significant positive correlation to the RV (TD MPI) **(r = 0.117, p = 0.01)** (Fig. 8A) while it shows a negative correlation with T E/A ratio **(r = –0.164, *p* = 0.013)** (Fig. 8B).

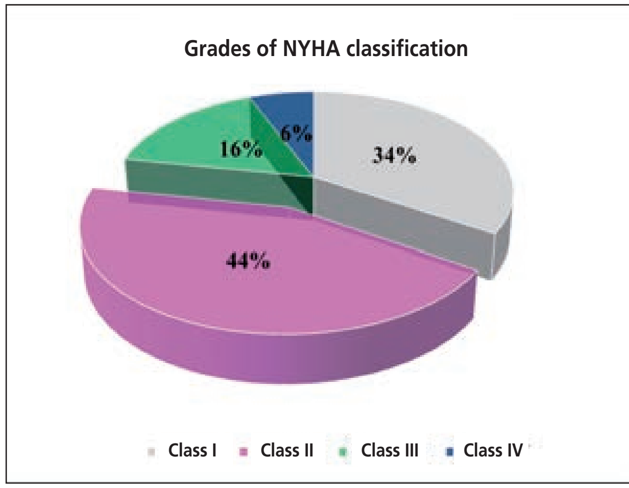


Fig. 7 – New York Heart Association (NYHA) functional classification of diastolic DHF group.

Discussion

Diastolic heart failure is a major cause of morbidity and mortality. It is defined as symptoms of heart failure in a patient with preserved LV systolic function. It is characterized by a stiff left ventricle with decreased compliance and impaired relaxation, which leads to increased end-diastolic pressure. Hospital- and community-based reports indicate that about one fourth to one half of patients with heart failure have normal LV systolic function.

RV dysfunction has been observed in a variety of settings, including obesity, cystic fibrosis, chronic aortic stenosis and arterial hypertension.[27–29] The impairment of RV function in left-sided heart failure has been linked to ventricular interdependence, which is often present in heart failure being most apparent with changes in loading conditions such as those seen with volume loading.[30–32] In contrast to the left heart, few studies have examined the RV in HFpEF.[33,34]

The current study enrolled 100 subjects divided into two groups; a group of fifty patients with DHF compared to fifty healthy subjects as controls. The mean age of the patients with DHF was 50.9±7.7 years old.

Concordant with previous studies[35] that found the prevalence of RV systolic dysfunction in patients with HFpEF was one third to one half, we found that the prevalence of RV systolic dysfunction in patients with DHF was 30–36%.

A recent study found that RV diastolic and systolic dysfunction was found in 60% and 30%, respectively, in hypertensive patients. Possible causes of these structural and functional changes in the RV are translation of the increased LV filling pressure in the pulmonary circulation and interaction of the right and left ventricle.[36]

Yu et al.[37] found that RV diastolic dysfunction is common in patients with heart failure as nearly 60% of patients had prolonged tricuspid isovolumic relaxation time and 55% of patients had reversed tricuspid E/A ratio. However, the study reported the prevalence in overall heart failure patients irrespective of reduced or preserved ejection fraction heart failure. We found that tricuspid

Table 4 – Demographic characteristics and clinical parameters of the study groups

Non-DHF Group		DHF Group	
Variables	**Mean±SD**	**Mean±SD**	***p*-value**
Age (years)	50.9±7.7	54.3±12.1	0.099
Gender (%)	Males 24 (48%) Females 26 (52%)	Males 24 (48%) Females 26 (52%)	1.000
SBP (mmHg)	120 (100–130)	150 (130–170)	**<0.001**
DBP (mmHg)	80 (70–85)	90 (70–120)	**<0.001**

DBP – diastolic blood pressure; DHF – diastolic heart failure; SD – standard deviation; SBP – systolic blood pressure.

Table 5 – Echocardiographic parameters of the study groups

Non-DHF Group		DHF Group	
Variables	**Mean±SD/ Median (range)/N**	**Mean±SD/ Median (range)/N**	***p*-value**
AO (cm)	2.6±0.2	3.0±0.3	**<0.001**
LA (cm)	3.0±0.3	3.9±0.3	**<0.001**
SWT (cm)	1.0 (0.8–1.1)	1.1 (1.0–1.5)	**<0.001**
PWT (cm)	0.9 (0.8–1.1)	1.0 (0.7–1.6)	**<0.001**
LVEDD (cm)	3.9±0.2	4.7±0.4	**<0.001**
LVESD (cm)	2.6±0.2	3.2±0.4	**<0.001**
EF (%)	65.4±3.8	58.2±4.3	**<0.001**
FS (%)	34.0 (27–38)	32.0 (26–36)	**0.001**
ME/A	1.2±0.1	1.0±0.4	**0.002**

AO – aortic root diameter; EF – ejection fraction; FS – fraction shortening; LA – left atrium diameter; LVEDD – left ventricle end-diastolic diameter; LVESD – left ventricle end-systolic diameter; ME/A – mitral E/A ratio; PWT – posterior wall thickness; SWT – septum wall thickness.

Table 6 – Right ventricular dimensions and function in the study groups

Non-DHF Group		DHF Group	
Variables	**Mean±SD/Median (range)/N**	**Mean ±SD/Median (range)/N**	***p*-value**
Chamber sizes			
RVBD (cm)	3.2 (3–4)	4.0 (4–4)	**<0.001**
RVMD (cm)	2.6 (2.3–3.2)	3.3 (2.8–3.7)	**<0.001**
RVLD (cm)	6.7 (5.8–7.2)	7.6 (6.5–8.8)	**<0.001**
Systolic function			
TAPSE (cm)	2.4 (2.1–2.6)	1.9 (1.3–2.3)	**<0.001**
RV S` (cm/s)	13.8±1.3	11.4±2.4	**<0.001**
TDMPI	0.4±0.04	0.5±0.07	**<0.001**
RV FAC (%)	48.7±1.4	42.8±7.3	**<0.001**
Diastolic function			
TE/A ratio	1.4±0.1	0.7±0.2	**<0.001**
T E/E` ratio	3.9±0.2	6.9±2.2	**<0.001**
TDT (ms)	177.9±5.8	204.9±33.7	**<0.001**

DHF – diastolic heart failure; RVBD – right ventricle basal diameter; RVFAC – RV fraction area change; RVLD – right ventricle longitudinal diameter; RVMD – right ventricle mid-cavity diameter; RV S` – peak systolic tricuspid annular tissue velocity; SD – standard deviation; TAPSE – tricuspid annular plane systolic excursion; TDMPI – tissue Doppler myocardial performance index; TDT – tricuspid deceleration time; TE/A – tricuspid E/A ratio.

E/A ratio was significantly decreased in DHF. Moreover, it was negatively correlated with systolic and diastolic blood pressure.

Previous studies[38] demonstrated that tricuspid and mitral wave velocities have a similar pattern in patients with systemic hypertension.

Cittadini et al.[39] stated that RV E/A ratio was strongly related to homologous LV E/A ratio. This independent association suggests a functional interaction of wall passive diastolic properties between the two ventricles developing during LV overload pressure.

Our results were also in agreement with Myslinski et al.[40] who assessed the RV diastolic function in hypertensive subjects and demonstrated that impairment of LV diastolic function is associated with diastolic disturbances of the RV. The current study demonstrated a similar pattern of tricuspid and mitral wave velocities with a significant statistical correlation was found between the mitral and the tricuspid E/A ratio. Our study showed that there is a significant relation between the systolic blood pressure, diastolic blood pressure and RV diastolic function evidenced by reduction of tricuspid E/A ratio and prolongation of relaxation time.

These results were supported by Cicala et al.[29] who studied RV longitudinal function in arterial systemic hypertension by pulsed tissue Doppler and found that arterial systemic hypertension was associated with RV longitudinal diastolic dysfunction.

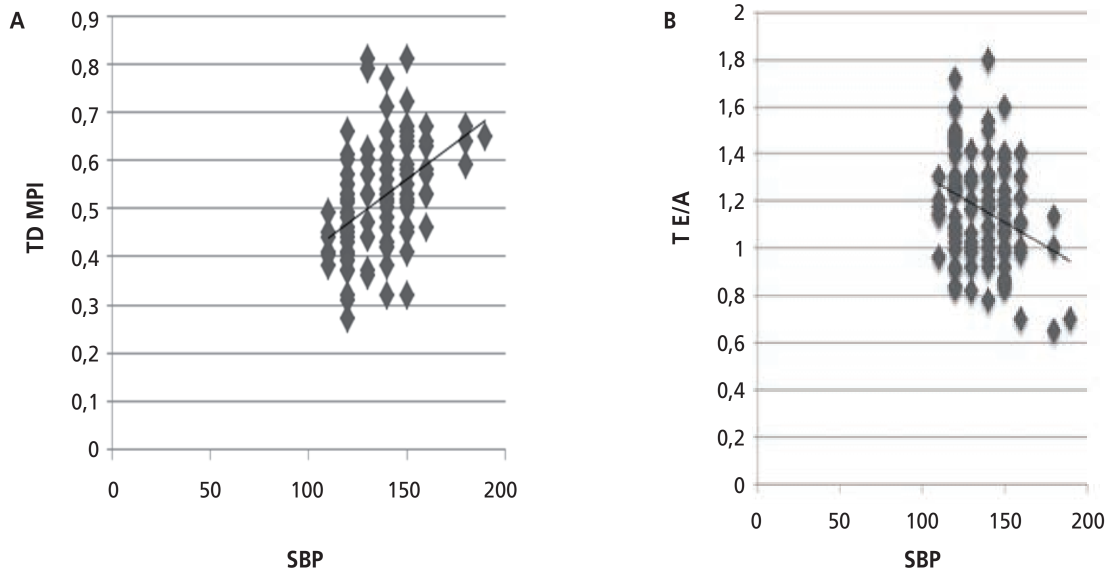


Fig. 8 – (A) Scatter plot showing the correlation between systolic blood pressure (SBP) and right ventricle tissue Doppler myocardial performance index TD MPI. (B) Scatter plot showing the correlation between systolic blood pressure (SBP) tricuspid E/A ratio (T E/A).

The current study found that systolic and diastolic blood pressure levels were positively correlated with septal wall thickness and negatively with mitral E/A ratio.

The mitral E/A ratio was positively correlated with tricuspid E/A ratio while it showed a negative correlation with right ventricular TDMPI.

Nunez et al.[41] demonstrated that RV wall hypertrophy occurred in hypertensive subjects. It can be deduced that the combination of increased posterior wall, septal wall and RV wall thickness will ultimately lead to progressive reduction in the RV end-diastolic dimensions before progressive dilatation may occur in the right heart.

The current study found that RV basal, mid and longitudinal diameters were increased in DHF group compared to the control group **(4.0 vs. 3.2 cm, *p* <0.001), (3.3 vs. 2.6 cm, *p* <0.001) and (7.6 vs. 6.7 cm, *p* <0.001),** respectively.

Conclusion

RV systolic and diastolic dysfunctions are common in patients with heart failure with preserved ejection fraction. This study recommended more emphasis on the assessment of the RV functions using different echocardiography modalities in the follow up of patients with diastolic heart failure. More studies are needed to clarify the relationship between RV dysfunction and clinical outcomes in patients with diastolic heart failure.

Conflicts of interest

There are no conflicts of interest.

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