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Heart Failure

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Abstract

Heart failure (HF) is a complex clinical syndrome that can result from any structural or functional cardiac disorder that impairs the ability of the ventricle to fill with or eject blood. The cardinal manifestations of HF are dyspnea and fatigue, which may limit exercise tolerance, and fluid retention, which may lead to pulmonary congestion and peripheral edema [1]. Atrial fibrillation (AF) is the most common arrhythmia in clinical practice, accounting for approximately one third of admissions resulting from cardiac rhythm disturbances [2].

Introduction

The association between AF and heart failure was appreciated almost a century ago [3]; Paul Dudley White noted, "Since auricular fibrillation so often complicates very serious heart disease, its occurrence may precipitate heart failure or even death, unless successful therapy is quickly instituted [4]. The reported prevalence of AF in modern heart failure series ranges from 13% to 27% [5-9]. Moreover, the prevalence of AF in patients with heart failure increased in parallel with the severity of the disease, ranging from 5% in patients with mild to 10% to 26% among patients with moderate up to 50% in patients with severe heart failure [10].

The impact of right ventricular function on survival in patients with advanced HF has been underlined by studies showing that left ventricular function loses its prognostic value in patients with an ejection fraction of less than 25%, while a preserved right ventricular ejection fraction proved to be predictive for exercise capacity and survival even in advanced HF. These studies have supported the need for a method which allows a simple and rapid evaluation of right ventricular function [11].

Peak systolic tricuspid annular velocity determined by Doppler tissue imaging is a simple parameter with reasonable correlation to right ventricular ejection fraction (EF). A low peak systolic tricuspid annular velocity proved to have high predictive accuracy for right ventricular dysfunction (EF<45%) determined by radionuclide ventriculography [12].

Methods

Our study was a prospective analysis of 40 consecutive patients who were admitted to Assiut University Hospital with chronic AF and impaired LV systolic function (EF≤45%). Patients with severe comorbid conditions, decreased life expectancy from other non-cardiac causes eg. Malignancies, primary lung diseases, or primary tricuspid valve disease were excluded from the study. The protocol was accepted by the medical ethics in human investigation committee of our institution.

All patients were subjected to full history taking, complete general and cardiac examination, and twelve leads ECG. Conventional echocardiography was done for all the study population at the beginning of the study. Assessment of cardiac dimensions and functions was done where left atrial (LA) and LV dimensions were measured using M-Mode in the parasternal long axis view. LV systolic functions were assessed using 2D Simpsons's method from both apical 2-chambers and apical 4-chambers views, to measure EDV, ESV, and EF%. Diastolic functions were evaluated by transmitral flow where total diastolic filling time, and E wave deceleration time were assessed. Right ventricular diameter was measured by M-Mode of paratsternal short axis viewat the level of papillary muscles. RVEF was assessed by Simpson's method in apical four chamber and apical two chamber views.

PWTDI of TVA was recorded from apical 4-chamber view where tricuspid annular systolic and diastolic velocities were acquired at the junction of the right ventricular free wall and the anterior leaflet of the tricuspid valve. Lateral S velocity, Lateral E velocity, Time to Lateral S, Time to Lateral E, Medial S velocity and Medial E velocity were recorded.

The patients were followed up for six months for development of clinical adverse events in the form of: readmission with heart failure, increased diuretic use, and thromboembolic manifestations. The primary end point was cardiac death. Correlations were done between the occurrence of cardiovascular events and conventional echocardiographic parameters including LA diameter, LVEDD, LVEF and RVEF. Events were correlated to tricuspid annulus pulsed wave tissue Doppler findings including Lateral S velocity, Lateral E velocity, Time to Lateral S, Time to Lateal E, Medial S velocity and Medial E velocity.

Statistical Analysis

Data were analyzed by statistical package for the social sciences (SPSS, version 16.0). The ranges, means, standard deviations were calculated for interval and ordinal variables and the frequencies and percentages for categorical variables. Univariate correlations were estimated between the occurrence of cardiovascular events and conventional echocardiographic parameters including LA diameter, LVEDD, LVEF and RVEF using Pearson correlation coefficient (r). Events were also correlated to tricuspid annulus pulsed wave tissue Doppler findings including Lateral S velocity, Lateral E velocity, Time to Lateral S, Time to Lateal E, Medial S velocity and Medial E velocity.

The univariate correlation between conventional and PWTDI parameters of TVA and all included variables was assessed by Pearson correlation coefficient (r) which were calculated to detect the strength and significance of association between a pair of variables measured on the interval, ordinal, dichotomous scale in each patient group separately. The probability (P value) less than 0.05 was taken as the limit of statistical significance.

Results

In this study, the patient's mean age was 49.03 ± 12.19 years (ranging from 29 – 80 years). Number of males was 22 (55.0%) and number of females was 18 (45.0%).

Echocardiographic Findings

Baseline Conventional Echocardiographic findings (Table 1): We found that mean LA diameter was 5.25 ± 0.64 cm (ranging from 4.1 – 7.4 cm), and mean LVEDD was 6.05 ± 0.75cm (ranging from 4.6 – 7.5cm). Also we found that mean LVEF was 34.98 ± 7.36 % (ranging from 23.0 – 44.0 %), and mean RVEF was 32.85 ± 7.00% (ranging from 20.0 – 46.0%). RVEDV was 59.03 ± 38.76 (ranging from 14.0 – 204.0 ml), and RVESV was 42.67 ± 30.54 (ranging from 9.0 – 136.0 ml).

Table 1: Baseline Conventional echocardiographic findings.

	Mean ± SD	Range
LA diameter	5.25 ± 0.64	4.1 – 7.4
LVEDD	6.05 ± 0.75	4.6 – 7.5
LVEF%	34.98 ± 7.36	23.0 – 44.0
RVEF%	32.85 ± 7.00	20.0 – 46.0
RVEDV	59.03 ± 38.76	14.0 – 204.0
RVESV	42.67 ± 30.54	9.0 – 136.0

Baseline Tricuspid Annulus pulsed wave tissue Doppler findings: In our study we found that the mean lateral S velocity was 8.46 ± 1.60 cm/sec (ranging from 5.8 – 13.8 cm/sec), while the mean lateral E velocity was 11.86 ± 2.37cm/sec (7.1 – 16.7c m/sec), and mean Time to Lateral S was 184.98 ± 29.14 m/sec (ranging from 127.0 – 265.0 m/sec).

Also we found that the mean Time to Lateral E was 452.08 ± 49.75 m/sec (ranging from 360.0 – 545.0 m/sec), and the mean Medial S velocity was 5.40 ± 1.07 cm/sec (ranging from 3.3 – 7.9cm/sec), and finally the mean Medial E velocity was 6.93 ± 2.24 cm/sec (ranging from 2.7 – 13.6 cm/sec) (Table 2).

Table 2: Baseline Tricuspid annulus pulsed wave tissue Doppler.

	Mean ± SD	Range
Lateral S Velocity	8.46 ± 1.60	5.8 – 13.8
Lateral E velocity	11.86 ± 2.37	7.1 – 16.7
Time to Lateral S	184.98 ± 29.14	127.0 – 265.0
Time to Lateral E	452.08 ± 49.75	360.0 – 545.0
Medial S velocity	5.40 ± 1.07	3.3 – 7.9
Medial E velocity	6.93 ± 2.24	2.7 – 13.6

Follow-up

Patients included in this study were Followed-up for six months for occurrence of cardiovascular events in the form of death, admission with HF, increase of the diuretics dose, and thromboembolic manifestations.

During the follow-up period, 10 patients reached the primary end point {10 admissions by HF (including three deaths), 6 cases increased the dose of diuretics (were admitted by HF), and one case of thrombo embolic manifestation (died)}.

Correlations were done between occurrence of events and echocardiographic findings of the patients (including conventional and tricuspid annulus pulsed wave tissue Doppler).

Conventional echocardiography with or without events: After the follow-up period, there was significant relation as regard both LVEF (with mean 28.60 ± 6.40% in patients with events, and 37.10 ± 6.45 % in patients without events, p=0.001) and RVEF (with mean 28.40 ± 7.88% in patients with events, and 34.33 ± 6.13% in patients without events, p=0.018) (Table 3).

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Table 3: Conventional echocardiographic findings recorded in patients with or without cardiovascular events during the follow up period.

	Event	No event	P-value
	Mean ± SD	Mean ± SD	
LA diameter	5.54 ± 0.96	5.16 ± 0.47	0.100
LVEDD	6.40 ± 0.63	5.94 ± 0.75	0.089
LVEF%	28.60 ± 6.40	37.10 ± 6.45	0.001*
RVEF%	28.40 ± 7.88	34.33 ± 6.13	0.018*

Tricuspid annulus pulsed wave tissue Doppler with or without events: There was significant relation only between Medial S velocity and occurrence of cardiovascular events (with mean 4.58 ± 0.97 cm/sec in patients with events, and 5.67 ± 0.97 cm/sec in patients without events, p=0.004) (Table 4) (Figure 1). There was insignificant relation between the occurrence of cardiovascular events and Lateral S Velocity (with mean 7.64 ± 1.29 cm/sec in patients with events, and 8.73 ± 1.61 cm/sec in patients without events, p=0.060). Also, there was insignificant relation between occurrence of cardiovascular events and Lateral E velocity (with mean 11.42 ± 2.91 cm/sec in patients with events, and 12.01 ± 2.21 cm/sec in patients without events, p=0.499), and with Time to Lateral S (with mean 198.40 ± 27.85msec in patients with events, and 180.50 ± 28.61 m/sec in patients without events, p=0.093). Time to Lateral E showed insignificant relation with the occurrence of events (with mean 476.30 ± 43.53 m/sec in patients with events, and 444.00 ± 49.70 m/sec in patients without events, p=0.075). And finally Medial E velocity also showed insignificant relation with the occurrence of events (with mean 6.00 ± 1.11 cm/sec in patients with events, and 7.24 ± 2.44 cm/sec in patients without events, p=0.132) (Table 4).

Table 4: Tricuspid annulus pulsed wave tissue Doppler with or without events.

	Event	No event	P-value
	Mean ± SD	Mean ± SD	
Lateral S Velocity	7.64 ± 1.29	8.73 ± 1.61	0.060
Lateral E velocity	11.42 ± 2.91	12.01 ± 2.21	0.499
Time to Lateral S	198.40 ± 27.85	180.50 ± 28.61	0.093
Time to Lateral E	476.30 ± 43.53	444.00 ± 49.70	0.075
Medial S velocity	4.58 ± 0.97	5.67 ± 0.97	0.004*
Medial E velocity	6.00 ± 1.11	7.24 ± 2.44	0.132

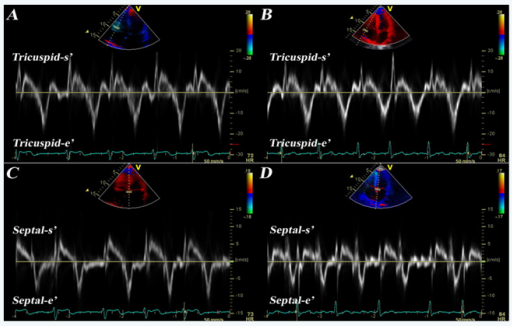

Figure 1: DTI at the tricuspid and septal annuli in patients without (A, C) and with (B, D) events. Both tricuspid s0 and septal e0 were severely reduced in patients with event.

Correlation between conventional echocardiography and tricuspid annulus pulsed wave tissue Doppler: There was significant correlations between RVEF and some of the DTI parameters of the tricuspid annulus (Lateral S peak velocity with p=0.004 and correlation coefficient (r) =0.441, Lateral E peak velocity with p=0.049 and correlation coefficient (r) =0.313, Time to lateral S with p=0.001 and correlation coefficient (r) =-0.508, Time to lateral E with p=0.001 and correlation coefficient (r) = -0.562, Medial S peak velocity with p=0.009 and correlation coefficient (r) = 0.410, and Medial E peak velocity with p=0.020 and correlation coefficient (r) = 0.366). Also there was significant correlations between LVEF and time to lateral S with p=0.030 and correlation coefficient (r) =-0.343 (Table 5). LVEDD was significantly correlated with Lateral E peak velocity with p=0.012 and correlation coefficient (r) = 0.395, and Time to lateral E with p=0.038and correlation coefficient (r) = 0.330. LA diameter was significantly correlated with Medial S velocity with p=0.039 and correlation coefficient (r) = -0.327 (Table 5) (Figure 2).

Discussion

Table 5: Correlation between conventional echocardiography and tricuspid annulus pulsed wave tissue Doppler.

		LA	LVEDD	LVEF%	RVEF%
Lateral S Velocity	r-value	-0.097	-0.125	0.186	0.441
	P-value	0.553	0.441	0.250	0.004*
Lateral E velocity	r-value	0.006	-0.395	0.261	0.313
	P-value	0.972	0.012*	0.104	0.049*
Time to Lateral S	r-value	0.304	0.174	-0.343	-0.508
	P-value	0.057	0.284	0.030*	0.001*
Time to Lateral E	r-value	0.277	0.330	-0.299	-0.562
	P-value	0.083	0.038*	0.061	0.001*
Medial S velocity	r-value	-0.327	-0.015	0.282	0.410
	P-value	0.039*	0.926	0.078	0.009*
Medial E velocity	r-value	-0.097	0.062	0.279	0.366
	P-value	0.551	0.704	0.081	0.020*

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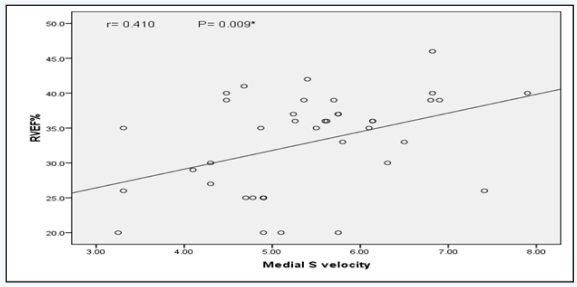

Figure 2: Correlation between both Medial S velocity and RVEF.

The assessment of prognosis in patients with AF has been performed in the clinical course of HF [13,14]. AF is believed to share pathophysiologic associations with hypertension and HF, although no definite etiology has been determined. Regarding the outcomes of HF, the concomitant presence of AF could be used to identify high-risk patients to prevent subsequent hospital admissions. In patients with AF, left ventricular (LV) diastolic or systolic dysfunction is frequently encountered, leading to left atrial (LA) enlargement and pressure elevation.

The electromechanical features of AF may impair ventricular filling and cause irregular contraction with poor ventricular rate control, resulting in a cardiomyopathy that is common in the left ventricle but may also be seen in right ventricle [15-17]. Consequently, AF commonly has adverse hemodynamic effects on both left and right ventricles, causing right ventricular (RV) dysfunction or HF. RV function is also considered to be an independent predictor of clinical events in HF, irrespective of LV functional severity [18,19]. Furthermore, Doppler tissue imaging (DTI) of the tricuspid valve (TV) annulus has been found to provide information about RV longitudinal function in previous studies [20]. Interestingly, systolic myocardial velocity as determined from the TV annulus could be a significant predictor of RV function and has proven to be a useful index in the prognosis of RV infarction [21].

However, few studies in the literature have examined DTI of the TV annulus in patients having HF with AF, although DTI is easily used for LV evaluation. In addition, patients with non-sinus rhythms such as AF have been usually excluded from echocardiographic studies. Despite the prognostic significance of AF in terms of HF, AF has not shown a consistent impact for prognosis in patients with HF, but rather, its impact might be dependent on the severity of HF [22]. Importantly, the association of TV DTI with AF has not been evaluated or focused in studies of HF.

Therefore, we hypothesized that TV DTI would be as important as mitral valve (MV) DTI for clinical outcomes, particularly in the setting of clinical AF. The goals of the present study were to quantify RV dysfunction and to assess prognostic value of tricuspid annulus tissue Doppler velocity in heart failure with atrial fibrillation.

In our study we used different parameters to assess RV dysfunctions as a predictive method to assess the prognosis of heart failure with atrial fibrillation. Our study includes 40 cases of heart failure (with ejection fraction less than 45%) with atrial fibrillation. We have done conventional echocardiography and DTI study of the tricuspid annulus including lateral S velocity, lateral E velocity, time to lateral S, time to lateral E, medial S velocity and medial E velocity. The patients were followed-up for 6 months for occurrence of cardiovascular events. Relations were done between the cardiovascular events occurred during the follow-up period and the echocardiographic findings at the beginning of the study. Moreover, correlations were done between the DTI of the TV and the conventional echocardiographic findings according to the occurrence of the cardiovascular events in the follow up period.

At the end of the study there were 3 deaths reported with a percentage of 7.5%, 10 admissions with heart failure with a percentage of 25%, 6 cases increased the dose of diuretics with a percentage of 15%, and there was one case of cerebrovascular stroke with a percentage of 2.5%. DTI of the tricuspid annulus revealed that the lower medial S velocity, the more significant relation with occurrence of cardiovascular events in the follow up period (with mean 4.58 ± 0.97 cm/sec in patients with events, and 5.67 ± 0.97 cm/sec in patients without events, p=0.004). But there were no significant relation with occurrence of cardiovascular events and the other parameters of RV DTI including Lateral S, medial E and lateral E velocities. Those results were with the agreement with Kim et al. [23] who reported that most patients with left HF exhibit RV dysfunction, evidenced by low tricuspid annular DTI velocities including Medial S peak velocity. But we disagree with Kim et al. [23] in the significance of the medial E and Lateral S velocities as predictive of cardiovascular events [23].

We disagree in our study with Meluzin J et al. [24] as they reported in their study that the peak systolic annular velocity was significantly lower in patients with heart failure than the healthy subjects (10.3 +/- 2.6 cm. s(-1) vs 15.5 +/- 2.6 cm/sec, P < 0.001) [24]. In agreement with De Groote et al. who dedicated that in patients with moderate heart failure, RVEF in addition to the NYHA functional classification was an independent predictor of survival and of major cardiac events [25]. We found significant relation between the occurrence of cardiovascular events and the lower the RVEF (with mean 28.40 ± 7.88% in patients with events, and 34.33 ± 6.13% in patients without events, p=0.018).

In agreement with Solomon et al. [26] who dedicated that LVEF is an important and powerful predictor of cardiovascular outcomes, including all-cause mortality, cardiovascular mortality, sudden death, heart failure–related death, fatal or nonfatal MI, and heart failure hospitalization. Every 10% reduction in ejection fraction below 45% was independently associated with a 39% increased risk for all-cause mortality,

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with the most common events experienced being sudden death and heart failure–related death [26]. We found in our study a significant relation between reduction of LVEF and the occurrence of cardiovascular events (with mean 28.60 ± 6.40% in patients with events, and 37.10 ± 6.45 % in patients without events, p=0.001).

In agreement with Kizer et al. [27] who reported in their population-based cohort, LA diameter independently predicted incident cardiovascular events after adjustment for established clinical, echocardiographic, and inflammatory risk factors [27]. We found in this study significant relation between cardiovascular events and the LA diameter (with mean 5.54 ± 0.96 cm in patients with events, and 5.16 ± 0.47 cm in patients without events, p=0.1). While in a study was done by Tsang et al. [28] in 2005, said that Indexed LA volume is a more robust cardiovascular risk marker than LA area or diameter in patients who are in sinus rhythm; however, in patients with AF, the predictive utility of LA size for future cardiovascular events seemed unsatisfactory, regardless of the method of LA quantitation [28].

In our study we made a correlation between the conventional echocardiographic findings of the patients and the DTI study of the tricuspid annulus, which revealed some positive correlations in various parameters. There was significant correlation between Time to lateral S and RVEF (with p=0.001 and correlation coefficient (r) =-0.508), which is supported by the study of Meluzin J et al [24]. Also Meluzin J et al. [24] reported that there was a good correlation between systolic annular velocity and right ventricular ejection fraction (r = 0.648, P <0.001). A systolic annular velocity < 11.5 cm/sec predicted right ventricular dysfunction (ejection fraction < 45%) with a sensitivity of 90% and a specificity of 85% [24]. which supports our study where we find a significant correlation between peak systolic annular velocity lateral S and RVEF with p=0.004 and correlation coefficient (r) =0.441.

In our study, there were various significant correlations between RVEF and other tricuspid annulus DTI parameters including Lateral E velocity, Time to lateral E, Medial S velocity, and Medial E velocity. Lateral S velocity showed significant correlation with LVEF with p=0.250 and correlation coefficient (r) = 0.186. LVEDD was significantly correlated in this study with two parameters, lateral E velocity and time to lateral E (p=0.012 correlation with coefficient (r) =-0.395, and p=0.038 with correlation coefficient (r) = 0.330, respectively). LA diameter was only significantly related to Medial S velocity with p=0.039 and correlation coefficient (r) = -0.327.

Conclusion

RV functions including RVEF and Doppler tissue imaging)DTI(of tricuspid annulus can be a good predictor of cardiovascular events and the prognosis of heart failure with atrial fibrillation.

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