Original Article

Diastolic Dysfunction in Left Ventricular Hypertrophy in Hypertensive Patients with Normal Ejection Fraction: A Cross-Sectional Study in Ibn Al-Bitar Center for Cardiac Surgery

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Abstract

Background: Hypertension is the main cause of death and left ventricular (LV) diastolic dysfunction. LV hypertrophy (LVH) in the hypertensive patient has two types: eccentric and concentric which are classified according to the posterior wall thickness to LV end-diastolic dimensions. **Aim of Study**: The left ventricular diastolic function in age- and sex-matched patients with hypertension and and normal left ventricular ejection fraction was compared in the study. **Patients and Methods**: A total of 110 patients were enrolled in this study in Ibn Al-Bitar Cardiac Center from April 2013 to June 2014. History and examination were performed on each patient, then LV mass index (LVMI) was measured by echocardiography and patients were classified into two groups eccentric and concentric LVH. LV diastolic function was differentiated using echocardiography by measurements of left atrial volume index (LAVI), E wave, and A waves, the (E/A) ratio, transmitral deceleration time (DT), e' wave and the (E/e'). **Results**: LVMIs did not differ between the concentric and eccentric LVH groups. The diastolic function parameters such as LAVI, E/A ratio DT, and e' wave did not differ in both groups. Concentric LVH has E/e' significantly higher (mean ± standard deviation [SD] =12.82 ± 4.4) than those with eccentric LVH (mean ± SD = 10.37 ± 3.2). **Conclusion**: In patients with hypertension and LVH, concentric LVH group may be susceptible to worse diastolic dysfunction of LV than the eccentric LVH group with a similar LVMI, so we can predict the severity of diastolic dysfunction (higher E/e' ratio) by classifying LVH into concentric and eccentric.

Keywords: Hypertension, Left ventricular diastolic dysfunction, Left Ventricular Hypertrophy

Introduction

Hypertension is the most prevalent cardiovascular disorder, affecting 20%–50% of the adult population worldwide.[1] Systolic hypertension is the most common antecedent disease leading to heart failure with preserved ejection fraction (HFpEF), which is present in more than 85% of patients.[2]

Since approximately half of the patients with new diagnoses of heart failure have HFpEF, the measurement of left ventricular (LV) diastolic function must be important in assessing of patients presented with heart failure or dyspnea on exertion.[3]

Nowadays, the best noninvasive way to measure diastolic function and to evaluate filling pressures is echocardiography, during echocardiography test using two-dimensional, M-mode, blood flow Doppler, tissue doppler, and color Doppler echocardiography to estimate diastolic function.[3] Hence, this study was done to examine and compare the left ventricular diastolic dysfunction in concentric and eccentric left ventricle hypertrophy in patients with hypertension.

Aim of the study

The LV diastolic function between age- and sex-matched hypertensive patients with eccentric and concentric LV

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hypertrophy (LVH) and normal LV ejection fraction (LVEF) was measured and compared in the study.

Patients and Methods

The study is a cross-section performed in Ibn Al-Betar Cardiac Surgery Center from April 2013 to June 2014 when 110 patients with systemic arterial hypertension and normal LVEFs were enrolled in this study. Hypertension is considered when systolic blood pressure (BP) ≥140 mmHg and/or diastolic BP ≥80 mmHg,[4] measuring the BP using sphygmomanometer.[5] The patients should be on at least single antihypertensive drug.

Exclusion criteria

Patients with one or more of the following conditions were excluded from this study:

1. Ischemic heart disease (considered if one or more of the following present: myocardial infarction, angina, history of positive cardiac stress test, use of sublingual nitroglycerin, and currently presented with chest pain mostly due to coronary ischemia, or electrocardiography with significant Q waves)[5]
2. LV systolic dysfunction (LVEF <55%)
3. Significant cardiac arrhythmias
4. Valvular heart disease
5. Dilated, restrictive, or hypertrophic cardiomyopathies
6. Pericardial disease
7. Hemodynamically significant congenital heart disease
8. Diabetes mellitus
9. Chronic renal failure, stage 4 or less
10. Poor echocardiographic window.

Data collection

After applying inclusion and exclusion criteria on all patients, proper history and examination were performed; body mass index (BMI) and body surface area (BSA) were calculated. Fasting blood sugar, renal function test, 12-lead electrocardiography, and transthoracic echocardiography were performed on all patients.

Echocardiography

Transthoracic echocardiographic examinations were performed to assess cardiac structural changes and cardiac function. Two-dimensional and M-mode echocardiography was performed using Philips system echocardiography machine EI33. The following LV parameters were measured by M-mode echocardiography: the thickness of interventricular septum (SWT in mm), thickness of the posterior wall of LV (PWT in mm), and the end-diastolic dimension of LV (LVIDd in mm), all are measured at the level of the LV minor axis, approximately at the mitral valve leaflet tips; left atrial volume was calculated by biplane area–length formula at the end of LV systole and LV volume index (LAVI) was calculated by dividing left atrial volume of each patient by BSA.[6] LV mass was measured by the American Society of Echocardiography method.[6]

The LVEF was measured by linear measurement,[7] and it was considered as the indicator of LV systolic function. The indicators of LV diastolic function were transmitral flow velocity using Doppler echocardiography.[3] Transmitral flow velocities (E wave (cm/s) and A wave (cm/s)) were recorded from the apical four chambers' view and during pulse doppler examination we put 1–3 mm sample volume on the mitral leaflet tips, deceleration time (DT) and the E/A waves ratio recorded.[3] Using tissue Doppler echocardiographic function, we estimate the velocity of the medial and lateral mitral annulus. 2D and M-mode echocardiography were measured also. From the apical four chambers' view, mitral annulus velocities were estimated. The sample volume was situated within 1 cm of lateral and septal insertion of the mitral leaflets and adjusted as 5 mm to assess the longitudinal excursion of the annulus of mitral valve annulus in the systole and diastole and their velocities averages were recorded.[3] Peak early diastolic velocity of the mitral annulus (e′) of three cardiac cycles was measured and recorded the mean.[8,9] During echocardiography test E/e′ ratio was considered as an indicator ofleft atrium pressure[10] and this ratio increased with increase in severity of LV diastolic dysfunction, according to the American Society of Echocardiography.[3]

Statistical analysis

The statistical analysis of the data was performed using Statistical Package for the Social Sciences, version 25 (IBM Corp, Armonk, NY, USA). Data were arranged the following variables: mean, frequency, standard deviation, and percentage. The significant differences were identified using the following methods: independent means differences were tested by Student's-*t*-test, paired observations (or two dependent means) were tested using paired *t*-test, the differences among more than two independent means were tested using ANOVA test. Chi-square test (χ^2 -test) with the application of Yates correction or Fisher's exact test whenever applicable was used to test significant differences between different percentages. $P \leq 0.05$ was considered statistically significant.

Results

The number of patients in the current study was 110 hypertensive patients with normal ejection fraction, 67% (No. = 74) were male and 33% (No. = 36) were female, the mean of their ages was 57 years. By measuring the LV mass index (LVMI), 65 patients (59%) had LVH, 46 (42%) with concentric and 19 (17%) with eccentric LVH, as shown in Table 1.

The four groups had no significant statistical differences regarding their ages, gender distributions. Regarding their BMI of the patients, 25 (23%) of them were normal body weight (BMI = 18.5–24.9), 55 (50%) were overweight (BMI = 25–29.9), and 30 (27%) were obese (BMI = ≥30), but there was no significant difference between the four groups of patients regarding their BMI distributions ($P > 0.05$). BP, heart rate, and pharmacological group of antihypertensive drugs were statistically similar among the patient groups, as shown in Table 1.

Echocardiographic parameters: The parameters of heart chambers measurements and systolic LV function of the four groups are summarized in Table 2, and there were the same increases in SWT and PWT from group to group as follows: normal LV geometry group < concentric LV remodeling group < eccentric LVH group < concentric LVH group [$P < 0.001$ between-group significances, as shown in Table 2].

LVIDd was higher in the eccentric LVH group in comparison to normal LV geometry and concentric LV remodeling ($P < 0.01$, $P < 0.001$, respectively). The difference in LVIDd was nonsignificant between the concentric LVH group and the normal LV geometry group or the concentric LV remodeling group ($P > 0.05$) the mean of LVIDd of eccentric LVH was higher than in concentric LVH ($P < 0.001$).

Regarding LVMI, the patients with concentric and concentric LVH has higher LVMI than patients with normal and concentric LV remodeling group ($P < 0.001$). However, the difference in LVMI was non-significant between concentric and eccentric LVH ($P > 0.05$).

The systolic function of LV represented by the parameter LVEF was normal in all groups, and there were no significant differences between them ($P > 0.05$).

There was an increase in LAVI as the following: concentric LVH group > eccentric LVH group > concentric LV remodeling group > normal LV geometry group ($P < 0.001$ between-group significances), as shown in Table 3. There were no significant differences in LAVI between concentric LVH and eccentric LVH groups ($P > 0.05$), while both eccentric LVH and concentric LVH groups had significant statistical differences in comparison to either concentric LV remodeling or normal LV geometry groups ($P < 0.01$).

The echocardiographic parameters of LV diastolic function of the four groups are presented in Table 3. About 40% (No. = 44) of the patients in this study had diastolic dysfunction, 43% of them (No. =19) had concentric LVH, and 31% (No. = 14) had eccentric LVH.

No significant differences were observed between the four groups for E wave, A wave, and E/A ratio ($P > 0.05$). The E/A ratio was not significantly different when comparing concentric and eccentric LVH groups with the normal LV

Table 1: Clinical features of patient groups with different types of left ventricular wall thickness

Clinical characteristics	LV geometry (mean±SD)				*P*
	Normal LV geometry (*n*=27)	Concentric LV remodeling (*n*=18)	Eccentric LVH (*n*=19)	Concentric LVH (*n*=46)	
Age (years)	56.3±9.68	56.8±4.9	58.1±11.07	57.1±8.05	>0.05
Gender (*n*)					
Male	16	12	11	35	>0.05
Female	11	6	8	11	
BMI (kg/m^2)	27.4±3	27.2±2.7	28.3±3.0	28.0±3.2	>0.05
Types of antihypertensive medication (%)					
ACEI or ARB	65	71	72	64	>0.05
CCB	63	61	69	67	>0.05
BB	22	21	19	24	>0.05
D	34	32	31	29	>0.05
Systolic blood pressure (mmHg)	150±7.26	150±11.89	150±12.79	155±11.7	>0.05
DBP (mmHg)	75.9±6.51	75.0±8.40	78.4±10.68	77.3±8.93	>0.05
HR (beats/min)	76.7±8.77	76.0±1.68	78.4±9.55	79.8±6.79	>0.05

BMI: Body mass index, LV: Left ventricular, LVH: LV hypertrophy, SD: Standard deviation, DBP: Diastolic blood pressure, HR: Heart rate, ACEI: Angiotensin converting enzyme inhibitor, ARB: Angiotensin receptor blocker, CCB: Calcium channel blocker, BB: Beta blocker

Table 2: Echocardiographic values in the groups of patients with hypertension and different left ventricular wall thicknesses

Parameter	Mean±SD				
	Normal LV geometry (*n*=27)	Concentric LV Remodeling (*n*=18)	Eccentric LVH (*n*=19)	Concentric LVH (*n*=46)	*P*
SWT (cm)	0.98±0.08	1.05±0.09	1.18±0.07	1.30±0.17	<0.001
PWT (cm)	0.94±0.08	1.12±0.06	1.08±0.09	1.31±0.11	<0.001
LVIDd (cm)	5.09±0.34	4.86±0.24	5.48±0.36	4.96±0.25	<0.001
LVMI (g/m^2)	94.00±13.90	102.67±8.89	131.63±22.06	133.37±20.51	<0.001
LVEF (%)	63.37±4.33	63.44±4.08	62.63±3.56	64.05±4.47	>0.05

SD: Standard deviation, LV: Left ventricular, LVH: LV hypertrophy, LVIDd: LV end-diastolic internal diameter, LVMI: LV mass index, LVEF: LV ejection fraction, SWT: Septal wall thickness, PWT: Posterior wall thickness

Table 3: The echocardiographic parameter of left ventricular diastolic function of the four groups

Parameters	Mean±SD				*P*
	Normal LV geometry (*n*=27)	Concentric LV remodeling (*n*=18)	Eccentric LVH (*n*=19)	Concentric LVH (*n*=46)	
LAVI	25.44±3.21	26.00±3.24	29.15±3.94	30.54±4.66	<0.001
E wave	69.31±15.16	69.10±14.83	68.52±21.51	77.62±14.23	>0.05
A wave	79.67±18.06	84.90±11.24	85.54±8.73	89.71±21.62	>0.05
E/A ratio	0.881±0.125	0.828±0.214	0.813±0.299	0.890±0.185	>0.05
DT	248.1±57.01	210.6±46.11	237.1±40.82	246.6±48.69	>0.05
e’ wave	8.68±1.31	7.26±1.61	6.73±0.96	6.47±1.69	<0.001

SD: Standard deviation, LV: Left ventricular, LVH: LV hypertrophy, LAVI: Left atrial volume index, DT: Deceleration time

geometry group. The e′ was significantly different when comparing concentric and eccentric LVH groups with the normal LV geometry group ($P < 0.01$, and $P < 0.001$, respectively). When comparing concentric to eccentric LVH group, there were no significant differences in E/A ratio or e′. There were no significant differences in DT between the four groups when comparing eccentric and concentric LVH groups. There were the same increases in E/e› ratio as follows: concentric LVH > eccentric LVH > concentric LV remodeling > normal LV geometry ($P < 0.001$ between-group significances), also E/e’ ratio was significantly higher (worse) in the concentric LVH group in comparison to the eccentric LVH group ($P < 0.05$).

Discussion

In the study, we found that the mean of patient’s ages was 57 years, and 55% of them were overweight and 27% were obese, and this is similar to the result of Badran and Laher study about the prevalence of obesity in Arab countries.[7]

Diastolic dysfunction was found in 40% of the patients enrolled in this study which is in agreement with previous studies for the prevalence of diastolic dysfunction in Iraq[11] and similar with many other reports in Europe and the world.[12,13]

In hypertensive patients with normal LV systolic function when comparing measurements of diastolic functions of concentric and eccentric LVH, this leads to the following results.

LV mass index, which represents LVH severity, has no difference between eccentric and concentric LVH.

LA volume index did not differ between concentric and eccentric LVH despite the significant correlation of LA size and echocardiographic measures of diastolic function.[14] However, we must know that other causes can make LA dilated with normal LV diastolic function, such as four chambers’ dilatation due to bradycardia, high-cardiac output states, enlarged atria in AF, or AFL. Therefore, when LA volume measures it cannot considered alone as a predictor of LV filling pressure without considering other factors that can affect its measurement such as clinical features, other chambers dimensions, and Doppler measures of LV relaxation.[3] Other explanations could be the Doppler velocities and time intervals measured during the echocardiography study at the time of examination reflect the current diastolic pressures at this time, while left atrial volume often reflects the chronic effect of filling pressure on LA.[3]

DT and E/A ratio are other indicators of LV diastolic function in this study, there are no significant differences in their values between eccentric and concentric LVH, which can be explained by pseudo normalization of their values in grade two diastolic dysfunction,[3] which could affect their means and the statistical significance during evaluation; therefore, measurement of their values alone without correlation with other Doppler and echocardiographic parameter cannot reveal the real diastolic dysfunction severity.

The increase in E/e’ ratio in concentric LVH in comparison to eccentric LVH was in agreement with both Masugata *et al*.[15] and Mizuguchi *et al*.[16] who mention that E/e′ values were significantly higher in concentric LVH than in eccentric LVH, and LV mass index was higher in concentric LVH than in eccentric LVH in Mizugchi *et al*.’s report and similar in Masugata *et al*.’s report. However, the data in this study were disagreed with Cho *et al*.[17] who record that E/e′ does not significantly differ in the concentric and eccentric LVH. This increase in E/e′ reflects the increase in LA pressure that is caused by left ventricular diastolic dysfunction.[8,18] In spite of numerous epidemiological studies have demonstrated that increase LVMI was an independent risk of cardiovascular events, including stroke, coronary heart disease, and heart failure.[4,10,19] The finding of this study suggests that not only the severity of LVH, which is represented by LVMI, is important in hypertensive patients to predict hypertension complications, especially LV diastolic dysfunction, but also LV geometry type, which differentiated by relative wall thickness to the LV internal dimension is an important parameter for more accurate prediction of LV diastolic dysfunction.

Mullens *et al*.’s[20] study demonstrates that E/e′ may not have the benefit in measuring LV diastolic dysfunction in patients with severe diastolic and systolic LV dysfunction. While in this study, the patients with normal LV systolic function, so it will has rule in measuring LV diastolic dysfunction, and the measurement of E/e′ will predict the difference in LV diastolic dysfunction between concentric and eccentric LVH.

The possible by which E/e′ in patients with concentric LVH are more than patients with eccentric LVH could be due to that concentric LVH has thicker wall and less cavity than eccentric LVH, and this can cause more impairment in LV diastolic filling that cause greater LA pressure which represented by increased E/e′.

Another explanation of the increase in E/e′ (worse diastolic dysfunction) in concentric LVH than eccentric LVH in this study is that in the previous study,[16] the concentric LVH has decreased in LV longitudinal systolic function than in eccentric LVH (assessed by strain imaging technique of echocardiography).[14] In the present study, LVEF is considered the only indicator of LV systolic function rather than LV systolic longitudinal strain. Hence, the patient with concentric LVH has worse LV longitudinal systolic function that causes an increase in E/e′.

Conclusion

In patients with hypertension and normal ejection fraction by echocardiography, LV diastolic dysfunction will be more severe in concentric LVH than in eccentric LVH, and the assessing E/e′ is the only parameter that can help in measuring this difference.

Not only severity of LVH as assessed by the measurement of LV mass index is an important indicator of the severity of diastolic dysfunction but also classification of LVH to eccentric and concentric can help in predicting the severity of LV diastolic dysfunction in those patients.

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Conflicts of interest

There are no conflicts of interest.

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