Research Article

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Left Ventricular Diastolic Dysfunction Detected By Speckle Tracking In Hypertensive Patients with Preserved Ejection Fraction

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Abstract

Objectives: *To detect early diastolic dysfunction in the left ventricle in hypertensive patients with preserved ejection fraction using 2D speckle tracking echocardiography.*

Methods: *This is a prospective study that was carried on (30) hypertensive patients referred to Al Azhar university hospital outpatient clinic for evaluation and treatment of hypertension and (20) age and sex matched healthy volunteers as a control group. All subjects underwent convential echocardiographic examination and Assesment of diastolic dysfunction by speckle tracking.*

Conclusion: *Impairment of diastolic function detected by speckle tracking in hypertensive patients (with and without LVH).*

Keywords: Hypertension, Speckle tracking, Echocardiography.

Introduction

Hypertension is a well-recognized risk factor for cardiovascular disease and a major contributor to a large percentage of heart failure cases as it causes left ventricular (LV) systolic pressure overload due to an increase in peripheral vascular resistance which results in various LV geometric changes that progresses to diastolic heart failure and/or heart failure with LV systolic dysfunction [1]. Early detection of LV dysfunction before the development of LVH may represent a clinical finding that would justify aggressive treatment aimed at reducing cardiovascular morbidity and mortality; it has to be considered in the assessment of global cardiovascular risk [2].

Advances in echocardiography over the last ten years have provided new methods of analysis particularly analysis of myocardial strain by speckle tracking which enables quantitative assessment of LV function with high level of diagnostic accuracy [3]. This technique can be used to study myocardial strain in all its dimensions longitudinal, circumferential, transversal, radial and twist. Strain analysis may detect subclinical cardiac involvement in hypertensive and thus identify asymptomatic patients at higher risk of developing adverse changes [4].

The aim of the study

To detect early diastolic dysfunction in the left ventricle in hypertensive patients with preserved ejection fraction using 2D speckle tracking echocardiography.

Patients and Methods

Study design

This is a prospective study that was carried from April 2015 to July 2016 on (30) hypertensive patients referred to Al Azhar university hospital outpatient clinic for evaluation and treatment of hypertension and (20) age and sex matched healthy volunteers as a control group. They were enrolled in the study after obtaining their written informed consent. Diagnosis of hypertension was based on ESH/ESC guidelines for management of hypertension if SBP P 140 mmHg and/or DBPP 90 mmHg on two or more hospital visits at one week interval [5].

The study population was divided into three groups:
Group I (Control Group): Included 20 normotensive healthy age and sex matched volunteers free from cardiovascular risk factors.

Group II: Included 15 hypertensive patients without echocardiographic criteria of LVH.

Group III: Included 15 hypertensive patients with echocardiographic criteria of LVH.

Exclusion criteria

It included patients with ejection fraction <50% or with symptoms or sign of heart failure, diabetes mellitus, patients with known coronary artery disease, patients with significant valvular disease and patients with atrial fibrillation or other rhythm disturbances.

Methods

The following data were collected:

- Complete and detailed medical History: With attention to Hypertension, DM and family history of premature coronary artery disease.
- Full clinical examination including body surface area [6], heart rate, rhythm, systolic, diastolic blood pressure, heart, and chest auscultation.
- Assessment of LV functions by conventional echocardiography.

Systolic function assessment

Measurement of LV ejection fraction (EF %) and LV fractional shortening (FS %) was performed to evaluate LV systolic function. By 2D echo, The LVEDV and LVESV were calculated from the apical 2-and 4-chamber views using a modified biplane Simpson's method. Ejection fraction (EF %) was calculated as percentage change of LV chamber volumes between diastole and systole. The LV ejection fraction (EF %) was automatically calculated as follows [7] : (EF %) = (EDV−ESV)/EDV×100.

Diastolic Function assessment

Pulsed wave Doppler (PW) echocardiography was used to evaluate LV diastolic function; Doppler studies were recorded from apical 4-chamber view, with a sample volume positioned within the inflow portion of the LV, midway between the annular margins of mitral valve.

4-Two-dimensional speckle tracking echocardiography (2D STE)

Longitudinal strain rate was assessed in the 6 LV walls and the software algorithm automatically segmented the LV into 18 equidistant segments and each segment was individually analyzed. The average value of peak early diastolic SR (SRe s-1), peak late diastolic SR (SRa s-1) at each segment (basal, mid and apical) and global LV diastolic SR obtained from averaging the peak values of 18 LV segments were calculated and used for comparisons between control and hypertensive groups . All variables in this study represent the mean value of measurements taken in 3 consecutive cardiac cycles.

Statistical analysis

Data management and analysis were performed using SPSS program; version 17. The numerical data were statistically presented in terms of mean and standard deviation. Categorical data were summarized as percentages. Comparisons between numerical variables were done by unpaired Student's t-test. Comparing categorical variables were done by Chi-square test or Fisher exact test for small sample size. A probability value $p<0.05$ was considered statistically significant, a P value <0.001 was considered highly significant and P value >0.05 was considered non-significant.

Results

Clinical, demographic and electrocardiographic characteristic

In the present study, there were no significant differences between the three groups as regards age and sex by inclusion criteria (Tables 1 and 2).

Data	Group I (Control)	Group II (No LVH)	Group III (with LVH)	ANOVA		Tukey's test		
	Mean ± SD	Mean ± SD	Mean ± SD	F	P-Value	P1	P2	P3
Age	50.5 ± 6.0	51.6 ± 5.1	52.2 ± 6.0	6.138	0.130	0.29	0.36	0.12

Table 1: Comparison between three groups was according to Age.

Sex		Groups				Chi-square	
		Group I (control) N =20	Group II (No LVH) N =40				
Female	N (%)	12 (60%)	9 (60%)	8 (53.3%)	29 (58%)	1.515	0.469
Male	N (%)	8 (40%)	6 (40%)	7 (46.6%)	21 (42%)		

Table 2: Comparison between three groups was according to Gender.

Conventional echocardiography

Left ventricular posterior wall thickness (PWd), LA dimensions, interventricular septal thickness (IVSd), left ventricular mass (LVM) and left ventricular mass index (LVMI) were higher in hypertensive patients with LVH (group III) than hypertensive patients without LVH (group II) and the control group (group I), while E/A ratio was lower in hypertensive patients (groups II and III) than in the control group (group I) (Tables 3 and 4).

2D-speckle tracking imaging

There was a stepwise reductin in the global early diastolic strain rate (SRe s_1) from group I (control) to group II (HTN without LVH) to group III (HTN with LVH) (Table 5) and Figure 1.

	Group I (Control)	Group II (No LVH)	Group III (With LVH)	ANOVA		Tukey's test		
	Mean ± SD	Mean ± SD	Mean ± SD	F	P-value	P1	P2	P3
FS%	36.30 ± 3.326	36.60 ±3.185	37.73 ± 3.588	1.629	0.201	0.301	0.944	0.277
EF%	65.60 ± 4.547	66.23 ± 4.022	67.58 ± 4.437	1.719	0.185	0.342	0.856	0.219
PWD (cm)	0.88 ± 0.120	0.93 ± 0.159	1.16 ± 0.087	46.675	0.0001	0.0001	0.323	0.0001
LVESD (cm)	3.02 ± 0.324	2.95 ± 0.272	3.130± 0.465	2.387	0.097	0.081	0.770	0.526
LVEDD (cm)	4.80 ± 0.494	4.55 ± 0.666	5.03 ± 0.328	8.544	0.0001	0.0001	0.208	0.222
IVSD (cm)	0.90 ± 0.123	1.00 ± 0.339	1.25 ± 0.085	19.810	0.0001	0.0001	0.218	0.0001

Table 3: Comparison between three groups according to Echocardiographic parameters.

	Group I	Group II	Group III	ANOVA		Tukey's test		
	Mean ± SD	Mean ± SD	Mean ± SD	F	P- value	P1	P2	P3
E (m/s)	0.90 ± 0.20	0.70 ± 0.15	0.78 ± 0.16	8.950	0.0001	0.047	0.001	0.0001
A (m/s)	0.67 ± 0.19	0.91 ± 0.14	0.80 ± 0.19	3.636	0.030	0.048	0.037	0.025

Table 4: Comparison between three groups according to E & A measurements.

	Group I	Group II	Group III	ANOVA		Tukey's test		
	(Control) Mean ± SD	(No LVH) Mean ± SD	(With LVH) Mean ± SD	F	P-value	P1	P2	P3
Apical Septal	1.711 ± 0.436	1.709 ± 0.541	1.139 ± 0.620	12.588	0.0001	0.0001	0.720	0.001
Mid Septal	1.418 ± 0.387	1.161 ± 0.431	0.942 ± 0.310	10.880	0.0001	0.030	0.039	0.0001
Basal Septal	1.057 ± 0.324	1.062 ± 0.446	0.950 ± 0.313	1.048	0.355	0.376	0.999	0.550
Basal Lateral	1.345 ± 0.576	1.392 ± 0.494	1.074 ± 0.464	4.450	0.014	0.015	0.936	0.123
Mid Lateral	1.217 ± 0.416	1.055 ± 0.366	0.996 ± 0.334	2.479	0.089	0.752	0.238	0.073
Apical Lateral	1.730 ± 0.344	1.409 ± 0.562	1.232 ± 0.493	6.665	0.002	0.257	0.053	0.001
Apical Inferior	1.578 ± 0.312	1.636 ± 0.573	1.103 ± 0.500	12.681	0.0001	0.0001	0.906	0.002
Mid Inferior	1.355 ± 0.252	1.162 ± 0.390	0.964 ± 0.392	7.906	0.001	0.048	0.140	0.001
Basal Inferior	1.510 ± 0.452	1.388 ± 0.530	1.043 ± 0.533	7.037	0.001	0.010	0.666	0.004
Basal Anterior	1.500 ± 0.501	1.164± 0.506	1.122 ± 0.336	5.254	0.007	0.904	0.019	0.007
Mid Anterior	1.423 ± 0.264	1.128± 0.431	1.049 ± 0.227	8.790	0.0001	0.538	0.005	0.0001
Apical Anterior	1.399 ± 0.354	1.559± 0.594	1.134 ± 0.379	8.168	0.001	0.0001	0.437	0.106
Apical Posterior	1.652 ± 0.581	1.229± 0.660	1.202 ± 0.488	4.531	0.013	0.977	0.025	0.016
Mid Posterior	1.491 ± 0.337	1.088± 0.509	1.131 ± 0.216	8.144	0.001	0.869	0.001	0.002
Basal Posterior	1.262 ± 0.252	1.345± 0.663	1.248 ± 0.429	0.393	0.676	0.676	0.826	0.994
Basal Anteroseptal	1.320 ± 0.443	1.011± 0.483	0.950 ± 0.331	5.452	0.006	0.790	0.023	0.005
Mid Anteroseptal	1.396 ± 0.423	1.114± 0.618	1.091 ± 0.370	2.836	0.064	0.976	0.099	0.068
Apical Anteseptal	1.665 ± 0.515	1.296± 0.653	1.307 ± 0.536	3.119	0.049	0.996	0.059	0.069

Table 5: Comparison of the study groups regarding LV early diastolic strain rate of all analyzed segments. P2 = Between group I & II, P3 = Between group I & III, P value > 0.05 = Highly significant.

	Group I	Group II	Group III	ANOVA		Tukey's test		
	(Control) Mean ± SD	(No LVH) Mean ± SD	(With LVH) Mean ± SD	F	P-value	P1	P2	P3
Apical Septal	0.787 ± 0.448	1.052± 0.338	1.111± 0.472	4.172	0.018	0.799	0.059	0.015
Mid Septal	0.731 ± 0.267	0.973 ± 0.294	0.997± 0.174	8.579	0.0001	0.907	0.002	0.0001
Basal Septal	0.814 ± 0.407	0.964 ± 0.329	0.974± 0.293	1.747	0.180	0.990	0.190	0.231
Basal Lateral	0.738 ± 0.234	0.909 ± 0.416	0.969± 0.518	1.907	0.154	0.809	0.326	0.132
Mid Lateral	0.698 ± 0.347	0.707 ± 0.359	0.787± 0.281	0.830	0.439	0.449	0.646	0.995
Apical Lateral	0.673 ± 0.489	1.011± 0.469	1.025± 0.487	4.141	0.019	0.990	0.031	0.023
Apical Inferior	0.876 ± 0.224	0.956 ± 0.435	1.165± 0.386	4.838	0.010	0.043	0.726	0.019
Mid Inferior	0.780 ± 0.194	0.850 ± 0.308	1.073± 0.356	7.926	0.001	0.005	0.686	0.002
Basal Inferior	0.654 ± 0.271	0.859 ± 0.391	1.058± 0.376	14.32	0.0001	0.105	0.0001	0.0001
Basal Anterior	0.864 ± 0.455	1.030 ± 0.458	1.087± 0.399	1.782	0.174	0.825	0.151	0.348
Mid Anterior	0.620 ± 0.133	0.854 ± 0.352	0.902± 0.225	7.559	0.001	0.709	0.006	0.001
Apical Anterior	0.579 ± 0.228	0.960 ± 0.547	0.997± 0.344	7.258	0.001	0.918	0.001	0.004
Apical Posterior	0.660 ± 0.385	1.059 ± 0.427	1.145 ±0.511	7.919	0.001	0.673	0.001	0.005
Mid Posterior	0.737 ± 0.449	0.900 ± 0.307	0.930± 0.289	2.354	0.100	0.914	0.093	0.181
Basal Posterior	0.769 ± 0.461	953 ± 0.517	1.064± 0.471	2.443	0.092	0.569	0.075	0.356
Basal AnteroSeptal	0.714 ± 0.351	1.207 ± 0.385	0.994± 0.348	12.46	0.0001	0.027	0.0001	0.016
Mid AnteroSeptal	0.584 ± 0.324	0.935 ± 0.373	1.085± 0.345	13.45	0.0001	0.143	0.001	0.0001
Apical AnteroSeptal	0.512 ± 0.334	1.030± 0.492	1.157± 0.490	13.88	0.0001	0.348	0.0001	0.0001

Table 6: Comparison of the study groups regarding LV early diastolic strain rate of all analyzed segments. P1= Between group II & III, P2= Between group I & II, > 0.05 = Insignificant, P < 0.05 = Significant, P < 0.001 = Highly significant.

On the other hand, the global late diastolic strain rate SRa s_1 was significantly increased in both group II (HTN without LVH) and group III (HTN with LVH) when compared to group I (control) as shown in Table 6 and Figure 2.

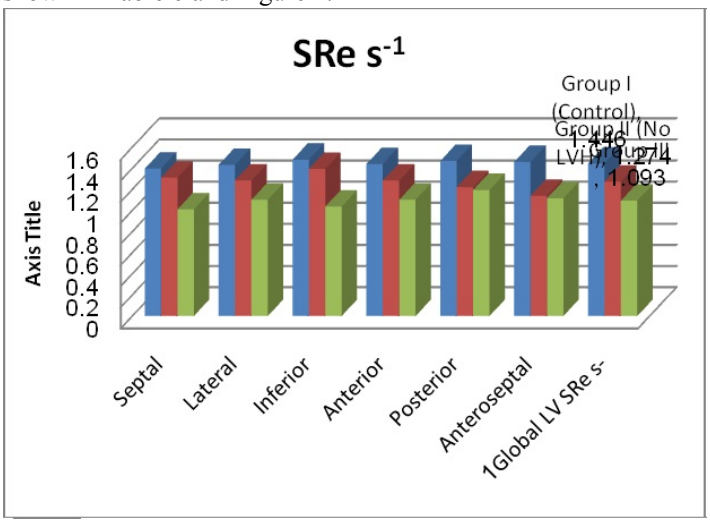

Figure 1: Comparison of the study groups regarding cumulative LV early diastolic strain rate.

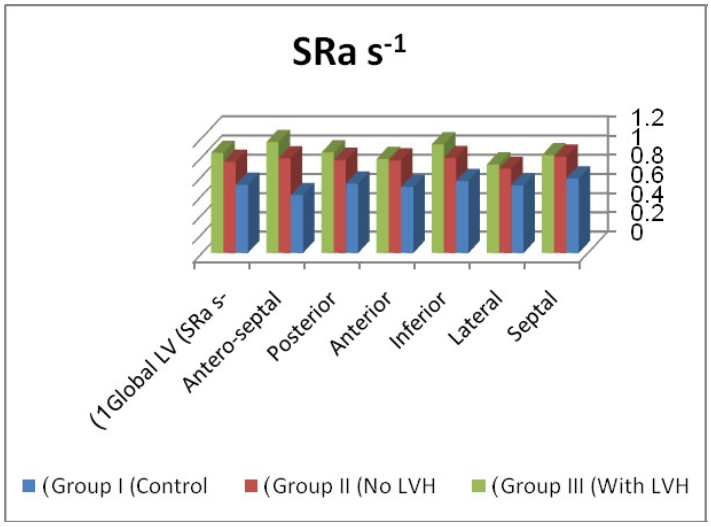

Figure 2: Comparison of the study groups regarding cumulative LV late diastolic strain rate.

Discussion

Strain (ε) is a measure of tissue deformation. As the ventricle contracts, muscle shortens in longitudinal and circumferential dimensions (a negative strain) and thickens or lengthens in radial direction (a positive strain). Strain rate (SR) is the local rate of deformation that measures the time course of deformation or strain per unit time [8].

In contrast to TDI, speckle tracking echocardiography is an angle-independent technique that allows an accurate assessment of segmental myocardial deformation by grey-scale based imaging analysis frame by frame. Moreover, the lack of angle-dependency is of great advantage as myocardial strain (ε) could be tracked in two dimensional echo imaging along the direction of the wall and not along the ultrasound beam [9].

The present study was designed to evaluate LV diastolic functions in hypertensive patients using 2D-speckle tracking echocardiography based longitudinal strain rate.

Regarding LV diastolic function assessed by conventional pulsed wave Doppler

The findings of the present study demonstrated significant impairment of LV diastolic function in hypertensive patients when compared with control group, as shown by inversion of the E/A ratio, in hypertensive patients with and without LVH, and it was more evident in hypertensive patients with LVH (group III).

The high prevalence of diastolic impairment among hypertensive patients may be attributed to LV thickening and the ultimate myocardial fibrosis with progression of the disease. This was explained by Cuocolo, et al. who demonstrated that, LV relaxation is impaired in subjects with LVH arising from chronic pressure overload owing to increased myocardial mass and resultant increase in interstitial connective tissue leading to increased LV stiffness [10].

This goes in harmony with the findings of Zabalgoitia, who investigated 665 hypertensive patients; 62% of them had LVH, by conventional echocardiography to evaluate mitral flow patterns and its relationship to LV systolic and diastolic functions and found that the inversion of the E/A ratio was the most prevalent pattern (79%) [11].

This was also supported by M. Dekleva, et al. who studied 30 hypertensive patients and demonstrated that all patients had preserved systolic function but impaired LV relaxation [12]. This was further explained by López, et al. who stated that, serological evidence of myocardial fibrosis in hypertensive heart disease (HHD) was demonstrated by experimental and clinical data and directly linked to abnormalities in diastolic function and myocardial stiffness [13].

Regarding LV diastolic function assessed by diastolic strain rate

The present study showed that the strain rate value was significantly reduced in both hypertensive patients with and without LVH in early diastole (at peak E) and in late diastole (at peak A) in comparison to control group. This goes with the results of Mu, et al. who studied 75 hypertensive patients with normal left ventricular geometry and 50 healthy persons and found that; early diastolic E′ peak value, late diastolic. A′ peak value and E′/A′ ratio of LV longitudinal strain rate, radial strain rate and circumferential strain rate were reduced in hypertensive patients compared with normal group [14].

This was in agreement with Goebel, et al. who found that, systolic strain rate and early diastolic strain rate quantified in longitudinal and circumferential directions were lower in hypertensive patients with LVH compared with those without LVH [15]. In addition, systolic twist rate and diastolic untwist rate were significantly lower

in this patient group. They concluded that, LVH in hypertensive patients predominantly affected longitudinal and circumferential deformation rate.

Huang Chun Yan studied 88 patients with essential hypertension in comparison to 30 normotensive ages and gender matched healthy volunteers served as controls. His Analysis showed that the early diastolic longitudinal strain rate and circumferential strain rate were lower in the essential hypertension group than normal controls. Hence, it was concluded that, speckle tracking imaging may be helpful for early detection of subclinical changes in LV diastolic function in patients with hypertension.

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