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Original Article

Role of speckle tracking echocardiography in detecting early left atrial dysfunction in hypertensive patients

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ABSTRACT

Background: Arterial hypertension adversely affects left atrial (LA) size and function, effect on function may precede effect on size. Many techniques were used to assess LA function but with pitfalls.
Objectives: Early detection of left atrial dysfunction with speckle tracking echocardiography in hypertensive patients with normal left atrial size.
Patients and methods: The study was conducted on 50 hypertensive patients and 50 age matched normotensive controls, all with normal LA volume index and free from any other cardiovascular disease that may affect the LA size or function. They were all subjected to history taking, clinical examination and echocardiographic study with assessment of LA functions [total LA stroke volume, LA expansion index by conventional 2D echocardiography and Global peak atrial longitudinal strain by speckle tracking (PALS)], left ventricular (LV) systolic and diastolic functions, and LV mass.
Results: Different indices of LA dysfunction (Total LA stroke volume, LA expansion index and global PALS) were significantly lower in the hypertensive group despite the normal LA volume index in all the studied subjects. The presence of diabetes mellitus (DM) and higher grade of LV diastolic dysfunction were significantly associated with lower global PALS. The higher age, systolic blood pressure (BP), body mass index (BMI), LA volume index, and LV mass index and the lower LA expansion index were associated with lower global PALS.
Conclusion: Speckle tracking echocardiography is a useful novel technique in detecting LA dysfunction in hypertension even before LA enlargement occurs.

1. Introduction

Arterial hypertension is associated with morphologic and functional LA abnormalities. An increase in LA size in patients with hypertension is a common finding in clinical practice, and the mechanisms underlying this enlargement have been extensively analyzed.[1] Most of studies included patients regardless of LA size. This raises the question of whether LA dysfunction in patients with hypertension may be detected in the absence of LA enlargement. This question may be of clinical interest, because LA size is often used as a surrogate marker of LA function in clinical practice.[2] Also, LA enlargement and dysfunction are considered risk factors for development of atrial fibrillation and cerebro-vascular strokes in hypertensive patients.[3]

Speckle-tracking echocardiography (STE) allows direct and angle-independent analysis of myocardial deformation, thus providing sensitive and reproducible indices of myocardial fiber dysfunction that overcome most of the limitations of Doppler-derived strain measures.[4] The assessment of LA strain dynamics by STE in hypertensive patients may be of particular interest in those with no evidence of LA enlargement, because it may provide additional information for the early detection of LA abnormalities.[5] So, we aimed for early detection of left atrial dysfunction by speckle tracking echocardiography in hypertensive patients with normal LA size.

2. Materials and methods

This was a cross sectional study that included 50 patients with systemic arterial hypertension (defined as Systolic BP $\geq$ 140 mmHg and/or diastolic BP $\geq$ 90 mmHg or Antihypertensive treat-

Abbreviations: LA, left atrium; LV, left ventricle; BP, blood pressure; BMI, body mass index; STE, speckle-tracking echocardiography; LASV, LA stroke volume; ROI, region of interest; HR, heart rate; DM, diabetes mellitus; PALS, peak atrial longitudinal strain.

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ment with a documented history of hypertension).[6] All patients should have an echocardiographic evidence of normal LA size (defined as LA volume index < 28 ml/m^2)[7] and 50 age matched non hypertensive control subjects. All were presented to ain shams university hospitals echo lab from June 2015 to march 2016. This study was approved by our Local Institutional Human Research Committee & subjects gave written informed consent.

Excluded from the study were patients with conditions that affect LA size and function like [a] Patients with documented coronary artery disease (defined as history of MI or revascularization, SWMA on echocardiography or positive stress test of any type) [b] Any type of cardiomyopathy (e.g. Dilated, ischemic, hypertrophic…) [c] Mitral valve disease [d] Atrial fibrillation-flutter.

The whole study population was subjected to

[I] History taking (a) Risk factors including: Age, gender, diabetes mellitus, hypertension, smoking, dyslipidemia and positive family history of cardiac disease. (b) Drug history "Types, doses, and duration" (c) History of any cardiac problem "e.g. ischemic heart diseases, heart failure, arrhythmias" (d) Paracardiac problem "Renal, broncho-pulmonary, or chronic liver disease".

[II] General and local cardiac examination including arterial blood pressure measurement (by conventional sphygmomanometer), pulse, body weight, body surface area and body mass index.

[III] Echocardiography was performed using Vivid S5 or Vivid 9; GE Medical Systems. A standard echocardiographic study using 2D, M-mode and Doppler techniques were performed in addition to speckle tracking for LA.

2.1. Standard assessment of left atrium

LA volumes were calculated from apical four-chamber and two-chamber views using the biplane Area-Length method.[7] Maximal and minimal LA volumes were measured just before mitral valve opening, and at mitral valve closure, respectively. The LA volume index was calculated in ml/m^2 automatically by the machine (Inputs: A1: Max. planimetered LA area in apical 4-chamber (A4C) view, A2: Max. planimetered LA area in apical 2-chamber (A2C) view, L: Length measured from back wall to line across mitral valve hinge points (cm), Weight (kg or Ib) and Height (cm or in)).

The following indices of LA function were calculated: Total LA stroke volume (LASV) could be obtained as the difference between maximal and minimal LA volumes. LA expansion index could be obtained as the ratio of total LASV to minimum LA volume $\times$ 100.[7]

2.2. Speckle tracking echocardiography

Recordings were processed using acoustic-tracking software (Echo Pac, GE, USA), allowing off-line semi-automated analysis of speckle-based strain. Good ECG was considered a prerequisite for a good analysis. Apical four-chamber, two-chamber and three-chamber images were recorded using conventional two-dimensional grayscale imaging, during breath hold. Care was taken to optimize visualization of the LA cavity and to maximize LA area in apical views, avoiding foreshortening of the left atrium.[8] Three consecutive heart cycles were recorded and averaged. The frame rate was set between 60 and 80 frames per second; these settings are recommended to combine temporal resolution with adequate spatial definition, and to enhance the feasibility of the frame-to-frame tracking technique. Offline analysis was then performed. LA endocardial surface was manually traced in both apical four- and two-chamber views by a point and click approach. An epicardial surface tracing was then automatically generated by the system, thus creating a region of interest (ROI).[9] To trace the ROI in the discontinuity of LA wall corresponding to pulmonary veins and LA appendage, the direction of LA endocardial and epicardial surfaces at the junction with these structures was extrapolated. After manual adjustment of ROI width and shape, the software divided the ROI into 6 segments, and the resulting tracking quality for each segment was automatically scored as either acceptable or non-acceptable, with the possibility of further manual correction.

Segments in which no adequate image quality could be obtained were rejected by the software and excluded from the analysis. In subjects with adequate image quality, a total of 12 segments were then analyzed.[10] Lastly the software generated the longitudinal strain curves for each segment and a mean curve of all segments that reflect the pathophysiology of atrial function.[11] Setting zero strain at LV end-diastole, the LA strain pattern is characterized by a predominant positive wave that peaks at the end of ventricular systole, followed by two distinct descending phases in early diastole and late diastole.[12]

The systolic component of LA strain mostly reflects LA reservoir function, whereas the early diastolic and late diastolic components mostly reflect LA conduit function and LA contractile function, respectively.[12] Global peak atrial longitudinal strain was then determined which is the most robust measure of LA function (mainly the reservoir function which is the most affected LA function in hypertension).[13]

LV systolic function was measured in 2D apical 4-chamber and 2-chamber views using biplane method of discs (modified Simpson's rule).[7]

LV diastolic function was determined using peak E velocity, peak A velocity, E/A ratio, and the deceleration time. The early diastolic E′ velocity and late diastolic A′ velocity were estimated by Doppler tissue imaging, by placing the sample volume at the septal annulus of the mitral valve and E/E′ ratio was calculated. The patients were graded according to LV diastolic dysfunction into 3 grades: grade 1 (impaired relaxation), grade 2 (pseudo-normal pattern) and grade III (restrictive pattern)[14] Fig. 1.

LV wall thickness: LV mass (LVM, in grams) was calculated using the Penn formula[15]:

$$\mathrm{LVM} = 1.04\ [(\mathrm{LVIDd} + \mathrm{PWTd} + \mathrm{IVSTd})3 - \mathrm{LVIDd}] - -13.6\,\mathrm{g}$$

where LVIDd is LV end-diastolic internal diameter; PWTd, diastolic posterior wall thickness; and IVSTd, diastolic interventricular septal thickness. LVM was subsequently indexed to body surface area (BSA) to obtain LV mass index.

2.3. Statistical analysis

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 20. Qualitative data were presented as number and percentages while quantitative data were presented as mean, standard deviations and ranges. The comparison between two groups with qualitative data were done by using Chi-square test while Fisher exact test was used instead of Chi-square test when the expected count in any cell was found less than 5. The comparison between two independent groups regarding quantitative data with parametric distribution was done by using Independent *t*-test. Correlation of global PALS with different risk factors was done using Pearson correlation coefficient.

3. Results

3.1. Demographic data

Both groups were matching regarding age, gender, HR, BMI and BSA (non-significant difference). DM was more common among

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