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Original Research Article

Echocardiographic assessment of left ventricular mass index and function in hypertensive patients with preserved ejection fraction

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ABSTRACT

Background: The aim of the present study is to detect left ventricular (LV) mass and to find out sub clinical LV diastolic dysfunction in hypertensive patients with preserved LV ejection fraction (EF) using echocardiographic parameters.
Methods: 96 patients with hypertension were randomly selected irrespective of their sex, race and risk factor and enrolled into this study. Left ventricular mass index (LVMI) and geometrical pattern LV structure were measured. Sub clinical diastolic dysfunction was also assessed by tissue Doppler.
Results: Out of 96 patients, 24 had ECG evidence of LV hypertrophy (LVH) 66 were having increased LVMI (154±20), rest 30 had normal LVMI (108±12). They were divided by LV geometrical pattern into concentric LVH (40), eccentric LVH (26), concentric remodeling (19) and normal (11). Diastolic dysfunction in these patients were assessed by E/E´ measurement which was abnormally increased in 42 out of 66 patients with increased LVMI (20±3.4) and 16 out of 30 patients with normal LVMI.
Conclusions: Echocardiographic examination help us to find out LVH precisely by calculating LVMI. It also reveals structural changes like concentric LVH, eccentric LVH, concentric remodeling. A significant number of patients with hypertension with normal LV ejection fraction has sub clinical LV diastolic dysfunction which was detected by tissue Doppler imaging (E/E′). The increase in LVMI with or without concentric LVH is an independent risk factor and prognostic marker for cardio vascular events that occur in hypertensive patients. In this study we infer that patients with increase in LVMI with concentric LVH pattern with normal ejection fraction needs more aggressive treatment and regular follow up to prevent cardiovascular complications.

Keywords: Echocardiography, LVH, LVMI, TDI, Hypertension

INTRODUCTION

Hypertension (HT) remains a major contributor to the global burden of disease. The prevalence of HT is 25% and 10% in urban and rural population respectively. According to World Health Organization (WHO) 2008 the prevalence of raised blood pressure (BP) is 32.5 among men and 31.7 in women. More than 70% older adult with incident MI, stroke, aortic dissection and heart failure had pre-existing hypertension.

Since left ventricle (LV) remains one of the main target organ of hypertension, echocardiographic measures of structure and function of LV not only help us to assess the disease progression but also the prognostic information in this setting.

Chronic hypertension causes increased pressure overload and subsequent increased wall stress results in left ventricular hypertrophy (LVH). However, in mild hypertension, LVH is may be absent and the first manifestation of hypertension is diastolic dysfunction.

This can be detected as grade one diastolic impairment, or impaired relaxation. If this is left untreated, filling pressures continue to rise, ventricular hypertrophy develops as a compensatory response to chronic pressure, and leads to the development of more severe disturbances in diastolic filling. Subsequently, LV remodelling will occur and left ventricular systolic function will become impaired. This will eventually cause severe LV dysfunction and end in heart failure.

It is established LVH detected by echocardiogram not only a powerful independent risk factor for cardiovascular morbidity, cardiovascular complications, and mortality and it also serve as a significant prognostic tool.[1]

The risk of hypertensives developing cardiovascular disease increases with increasing echocardiographic left ventricular mass index (LVMI), which itself an independent cardiovascular risk factor.[2]

LV geometric pattern in hypertensive patients provides additional prognostic information in. Concentric hypertrophy is associated with increased cardiovascular events after adjustment for other cardiovascular risk factors including LV mass.[3] Also, concentric hypertrophy showed the greatest mortality risk in patients suspected with coronary artery disease.[4]

Because impairment of LV long-axis function occurs at the early stages in many cardiac diseases, its assessment provides a very useful index in the evaluation of hypertensive patients.[5]

The LV longitudinal function can be assessed with atrioventricular plane displacement that was abnormal in hypertensive patients without notable systolic dysfunction. Tissue Doppler imaging is the new echocardiographic modality to measure mitral annular movement. It was found that mitral annular velocity was decreased in chronic hypertensive patients with normal ejection fraction.[6]

Echocardiography is also a useful imaging tool to measure LV diastolic function. Several echocardiographic modalities can be used to estimate LV filling pressure. The ratio E/E' can be a good indicator of LA pressure, and it is generally the most feasible marker for estimation of LV filling pressure.[7] Several studies have showed good correlation of this ratio with LV filling pressure.[8]

Hence the early detection of sub clinical LVH (LVMI) and LV dysfunction in hypertensive patients with preserved ejection fraction may represent a clinical finding that would justify aggressive treatment aimed at reducing cardiovascular mortality and morbidity.

Recent developments in the echocardiographic assessment of LV mass, pattern of LV hypertrophy and LV systolic and diastolic function in assessing the risk of developing morbidity and mortality have prompted us to do this study.

METHODS

This hospital based cross sectional study was conducted among convenient sample of 96 patients with systemic hypertension who were attending the hypertension clinic in Government Vellore Medical College Hospital, Vellore during the period of 1st August 2020 to end of November 2020, were randomly selected irrespective of their sex, race and risk factor and enrolled into this study. All the patients underwent routine blood test, 12 channel electrocardiography (ECG) and echocardiographic examination. The following inclusion and exclusion criteria were used to select the subjects in this study.

Inclusion criteria

Patients with well-established systemic hypertension on regular treatment, age group between 35 and 65 with normal LV function (EF>50) were included.

Exclusion criteria

Patients with age below 35 and above 65 years with co morbid illness like anaemia, malignancy, renal, liver and endocrine disease and coexisting coronary valvular, congenital heart diseases, cardiomyopathies, or rhythm disturbances were excluded. We also excluded patients who were on angiotensin-converting enzyme (ACE) or angiotensin-receptor blockers (ARB) for more than eight years of treatment.

Procedures

M-mode echocardiographic methods

M-mode echocardiography provides a single line of information at a higher frame rate than can be obtained by two-dimensional echocardiography. This technique enhances accurate determination of linear dimensions and improves quantitation of chamber size and wall thickness. Measurements of the internal diameter and wall thickness of the left ventricle were made at end-diastole. Left ventricular mass was calculated with the following formula:

$$Left\ ventricular\ mass\ (g) = 1.04[(LVID + IVST + PWT)3 - (LVID)3] - 13.6$$

Where LVID=left ventricular internal diameter measured at end-diastole; IVST=ventricular septal thickness; and PWT=posterior wall thickness. All values reported for left ventricular mass were divided by height.

Relative wall thickness was calculated using the equation given below.

$$Relative\ wall\ thickness = (IVST + PWT)/LVID$$

(Figure 1).

Cut points to identify left ventricular hypertrophy were set at 115 g/m for men and 95 g/m for women. Subjects were also categorized on the basis of their relative wall thickness, using 0.42 as a cut point. The above complicated calculation made very simple by using a calculator by Canadian echocardiographic society (Figure 1).

The patients with or without LV mass were divided into four groups on the basis of left ventricular geometry: concentric hypertrophy (LVH and increased relative wall thickness); eccentric hypertrophy (LVH and normal relative wall thickness); concentric remodelling (normal left ventricular mass and increased relative wall thickness); and normal geometry (normal left ventricular mass and normal relative wall thickness) (Figure 2).

2D pulsed-wave and tissue Doppler echocardiography

Tissue Doppler echocardiography (TDE) is specifically a form of echocardiography that measures the velocity of the heart muscle (myocardium) through the phases of one or more heartbeats by the Doppler effect (frequency shift) of the reflected ultrasound. The technique is the same as for flow Doppler echocardiography measuring flow velocities.

Mitral inflow was assessed in the apical four-chamber view, using 2D pulsed-wave Doppler echocardiography, with the Doppler beam aligned parallel to the direction of the sample volume at the leaflet tips. From the mitral inflow E and A wave peak velocities were measured (Figure 3a).

In the same view, under TDI mode mitral anulus velocities are recorded with tissue Doppler imaging, which is a modification of pulsed wave Doppler. A sample volume is placed over the lateral (left) or medial (right) annular position. Lateral anulus velocity is usually higher than the velocity from the medial anulus. Normal mitral anulus velocities are shown as late diastolic anulus velocity (A′); early diastolic anulus velocity (E′); and systolic anulus velocity S′) of LV. Thus ratio between mitral inflow velocity (E) and mitral annular velocity (E′) i.e. E/E′ is measured (Figure 3b).

RESULTS

Total number of 96 patients 24 patients had ECG evidence of LVH, 66 patients were having increased LVMI (154±20), and rest of the 30 had normal LVMI (108±12) (Figure 4). All these patients were divided by their geometrical pattern into concentric LVH (40 patients), eccentric LVH (26 patients), concentric remodeling (19 patients) and normal (11 patients) (Figure 5). As we measure the diastolic dysfunction in these patients by applying E/E´ formula it was abnormally increased in 42 out of 66 patients with increased LVMI (20±3.4) and 16 out of 30 patients with normal LVMI. The remaining patients showed normal values (16±1.4) (Figure 6).

Statistical analysis

Data collected was entered in MS excel and analysed using the Epi info version 6 software. Descriptive statistical measures like percentage, mean and standard deviation were applied. Data was presented as graphs as relevant.

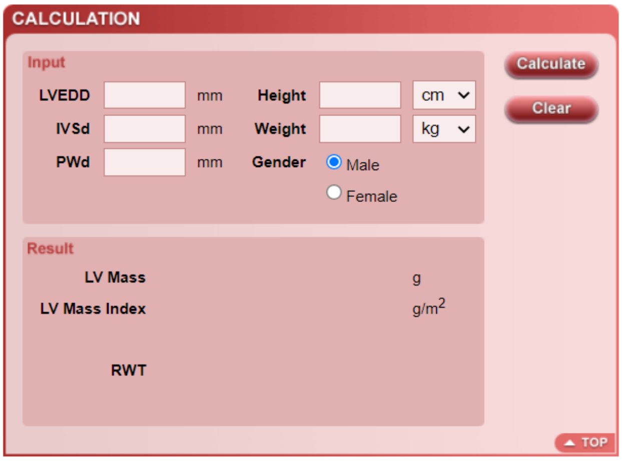

Figure 1: Canadian LVMI calculator.

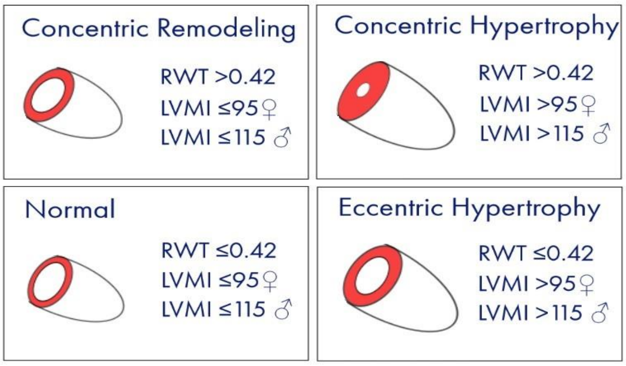

Figure 2: LV geometry in hypertension.

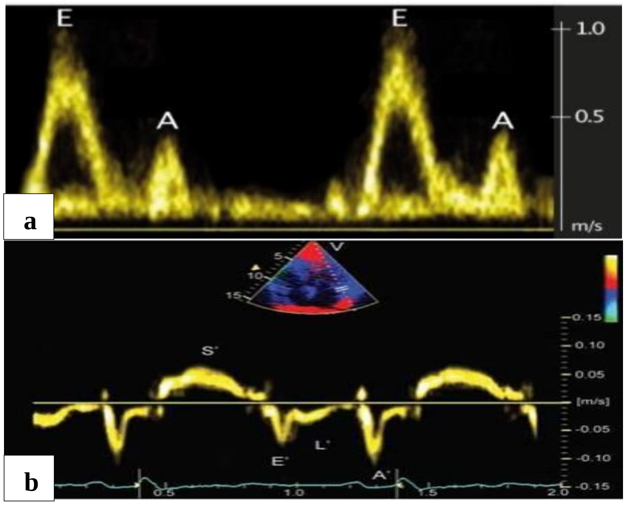

Figure 3: E/E′ measurement (a) 2D mitral pulsed Doppler, and (b) 2D mitral tissue Doppler.

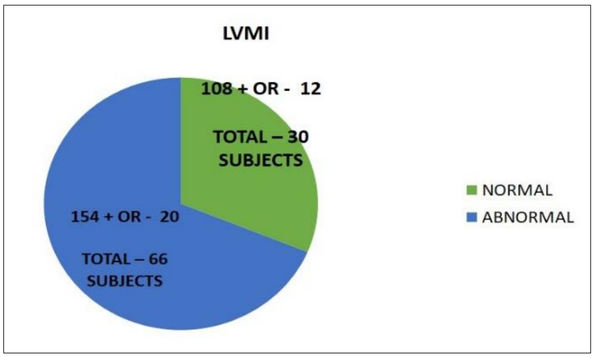

Figure 4: Distribution of LVMI (n=96).

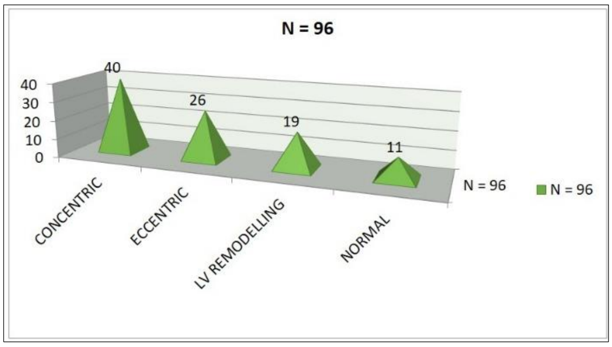

Figure 5: Distribution of LV geometrical pattern (n=96).

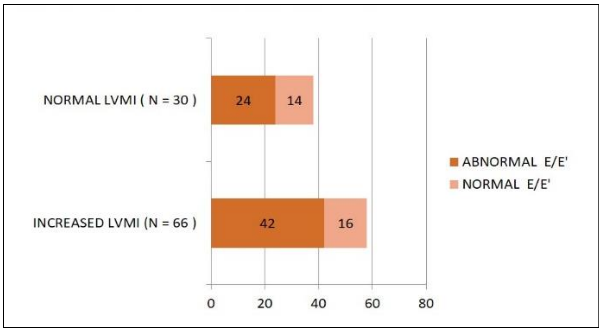

Figure 6: Abnormal E/E′ distribution (n=96).

DISCUSSION

Though there are various modalities to diagnose LVH such as echocardiography, computed tomography (CT) scan, magnetic resonance imaging (MRI) and more recently 3D echocardiography, but still ECG remains the first choice of diagnosing LVH because it is widely available, inexpensive, easy to perform and highly reproducible.

Echocardiogram is more sensitive than ECG in diagnosing LVH. The prevalence of LVH detected by echocardiography increases from 33% in young patients to 60% in old age group while the prevalence of LVH using ECG only increased from 11% in the younger age to 18% in the old people.[9] In this study we found 25% of patients with hypertension showed LVH by ECG (24 out of 96) and 68 % (66 out of 96) by echocardiogram.

Overall echocardiography is a good diagnostic tool in the determination of overall cardiovascular risk and helps in the selection of appropriate antihypertensive therapy. LVH detected on echocardiography is well-established risk factor for cardiovascular complications in hypertension, and in general population as well as in a variety of clinical settings. The exact value or range of values of LV mass at which it becomes a cardiovascular risk factor in hypertension is not clear.[10]

In view of the low sensitivity of ECG in detecting LVH, echocardiography has become the preferred mode of investigation in patients with hypertension. In addition to the detection of LVH precisely by LVMI, echocardiography also plays a significant role in demonstrating different geometric patterns of LVH in hypertensive patients. It also provide additional information on cardiac structure and functions, such as the degree of atrial enlargement and diastolic dysfunction.

Left ventricular mass and geometry

Mensah et al examined the prognostic value of LV mass in 193 subjects with essential hypertension stratified into 4 groups with progressively greater LV mass. The 12-year incidence of cardiovascular events was 64 % in patients with LV mass of 174 g/m^2 and 38% in patients with LV mass between 125 and 174 g/m^2.[11]

It is well established that LV mass increases myocardial oxygen consumption while reducing coronary blood flow reserve. It is also associated with an increase in atherosclerotic lesions. As the LV mass increases the chance of developing arrhythmias is also increases.[12]

The close association between established hypertensive disease and hypertrophy of the left ventricle and the thickening of blood vessels has been known for more than a century. In hypertensive patients, LVH is the earliest sign of cardiac damage, which also significantly increases the risk of major cardiovascular events.

In terms of prognostic value, it is established that echocardiographically determined LVH is one of the powerful independent risk factors for cardiovascular morbidity, cardiovascular complications, and mortality.[14]

It has been demonstrated that on the basis of LV mass and Relative wall thickness LV geometry was divided into four groups: concentric hypertrophy (LVH and increased relative wall thickness), eccentric hypertrophy (LVH and normal relative wall thickness), concentric remodelling (normal left ventricular mass and increased relative wall thickness), and normal geometry (normal left ventricular mass and normal relative wall thickness).[15,16]

The overall observations shows that left ventricular geometry is associated with clinical outcomes largely through its association with left ventricular mass. In the Framingham cohort, left ventricular mass was lowest in the group with a normal geometric pattern and increased progressively from the group with concentric remodelling to eccentric hypertrophy to concentric hypertrophy.[17]

In his report, Savage et al found that subjects with concentric hypertrophy had more severe LVH.[18]

Aronow et al in a study of hypertensive elderly subjects. After 3 years of follow-up, they found that concentric hypertrophy was associated with the highest coronary artery disease rate. They reported that the most important predictors of coronary events were the presence of left ventricular hypertrophy, total serum cholesterol level and presence of concentric LVH.[19]

In contrast Krumholz in Framingham heart study found that subjects who were free of cardiovascular disease had a prevalence of abnormal left ventricular geometry of 24% in men and 28% in women. According to this study the use of echocardiography to classify left ventricular geometry provided little incremental prognostic information beyond left ventricular mass and other cardiovascular risk factors.[20]

LV geometric pattern certainly provides additional prognostic information in hypertensive patients. Concentric hypertrophy is associated with increased cardiovascular events after adjustment for other cardiovascular risk factors including LV mass. Also, concentric hypertrophy showed the greatest mortality risk in patients suspected with coronary artery disease.[21,22]

In this observational study we also found concentric hypertrophy was the leading geometric pattern among patients with increased LV mass (>60 % i.e. 40 out of 66).

Early LV dysfunction in hypertension

Diastolic dysfunction is a common complication of chronically elevated blood pressure. The prevalence of asymptomatic diastolic dysfunction in patients with hypertension and without left ventricular hypertrophy may be as high as 33%.

Because impairment of LV long-axis function occurs at the early stages HT, its assessment provides a very useful index in the evaluation of hypertensive patients. The LV longitudinal function can be assessed with atrioventricular plane displacement that was abnormal in hypertensive patients without overt systolic dysfunction.

Longitudinal velocity of myocardium by TDI (E′) reflects relaxation of the myocardium. In normal subjects, E′ increases as the transmitral gradient increases with exertional or increased preload. In patients with impaired myocardial relaxation, E′ is reduced and does not increase as much as in normal subjects with increased preload. Therefore, a decrease in E′ is one of the earliest markers for diastolic dysfunction, and this decrease is present in all stages of diastolic dysfunction.[23]

Because E′ velocity remains reduced and mitral E velocity increases with higher filling pressure, the ratio between E and E′ (E/E′) increases and correlates well with LV filling pressure or pulmonary capillary wedge pressure. Several studies have showed good correlation if this ratio is <8 it shows normal filling pressure and if it is >15, is an indicator of increased LA filling pressure. Normally, the velocity from the lateral anulus is higher than the E′ velocity from the medial anulus (normal, ≥15 cm/s versus ≥10 cm/s).[24]

Although the movement of the mitral anulus can be recorded with M-mode echocardiography, tissue Doppler imaging is the method of choice for recording the longitudinal velocities of the mitral annulus.[25,26]

Nishikage demonstrated longitudinal early diastolic function was more prevalent, involving 33% of patients with normal LVMI, and more than 54% of those with increased LVMI.[24] We found 64 % with increased LVMI and (42 of 66), 53% with normal LV mass (16 of 30) had diastolic dysfunction in this study. Overall nearly two third i.e. 60% (58 out of 96) among study population were found to have sub clinical diastolic dysfunction.[27]

Subjects who developed hypertension through 20 years and sustained hypertensives probably have a higher LV mass index than normotensives, although not significant. However, they have a significantly lower E′ and higher E/E′ compared to normotensive controls.[28]

Limitations

There are some limitations to this study , the prime one is number of subjects included is small and most of the subjects were under various anti hypertensives and their influence on the outcome of this study were not completely excluded (except ACE inhibitors).

CONCLUSION

Echocardiographic examination is more sensitive than ECG in assessing LVH. LVMI calculated by using echocardiographic variables help us to find out LVH precisely. Echocardiographic examination also reveals various structural changes like concentric LVH, eccentric LVH, concentric remodeling.

A significant number of patients with hypertension with normal LV ejection fraction has sub clinical LV diastolic dysfunction which was detected by measuring longitudinal mitral annular velocity by tissue Doppler imaging (E/E′). The increase in LVMI with or without concentric LVH is an independent risk factor as well as prognostic marker for cardio vascular events that occur in hypertensives.

In this study we infer that patients with hypertension who has increase in LVMI with concentric LVH pattern with normal ejection fraction needs more aggressive treatment and regular follow up to prevent cardiovascular complications in future.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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