Original Article

Prevalence of Left Ventricular diastolic dysfunction in essential hypertension by echocardiography

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Abstract

Background: Diastolic dysfunction may be an early sign of cardiac diseases often antedating clinical or echocardiographic evidence of systolic dysfunction. Early detection of diastolic dysfunction may assist in additional risk stratification and subsequently can prevent the progression to heart failure. **Material and Methods:** In this cross sectional study, 50 consecutive newly detected or previously detected hypertensive patients were included. Evaluation of diastolic dysfunction was carried out by E/A ratio, Deceleration time and LA size. Ventricular diastolic function was measured by pulsed wave and continuous wave Doppler echocardiography. **Results:** The prevalence of left ventricular diastolic dysfunction documented by echocardiography was 54%.The prevalence of left ventricular hypertrophy was 70%. 85.88% of individuals with left ventricular hypertrophy also had left ventricular diastolic dysfunction on Doppler echocardiography; with an E/A ratio<1. In patients with left ventricular diastolic dysfunction on echocardiography, the prevalence of left ventricular hypertrophy was 65.71%. **Discussion:** Left ventricular diastolic dysfunction is prevalent inessential hypertensive patients and effort should be made to routinely screen them with echocardiography. Early recognition of diastolic dysfunction, especially in hypertensive patients, provides an opportunity to prevent progression to heart failure.

Key Word: Hypertension, Left ventricular diastolic dysfunction, Echocardiography, prevalence.

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INTRODUCTION

Hypertension increases the risk of cardiovascular disease for millions of people worldwide, and unfortunately the problem is only getting worse[1]. Essential hypertension accounts for 95% of all cases of hypertension. It remains a major modifiable risk factor for cardiovascular disease despite advances in pathophysiological understanding and the availability of effective treatment strategies[2]. Left ventricular hypertrophy confers an increased mortality independent of other cardiovascular risk factors. Recent studies have focused attention on the association of left ventricular hypertrophy with left ventricular diastolic dysfunction as the earliest evidence of impaired left ventricular function in hypertension[3]. Diastolic dysfunction may be an early sign of cardiac diseases (as in hypertension), often antedating clinical or echocardiographic evidence of systolic dysfunction. In addition, the degree of diastolic dysfunction may explain the difference in clinical symptoms between similar degrees of systolic dysfunction[4]. Early detection of diastolic dysfunction may assist in additional risk stratification and subsequently guide the introduction of appropriate pharmacological interventions. Diastolic dysfunction can be assessed by several methods[5]. Clinically, reduced ventricular compliance may be detected by the presence of an atrial (S4) gallop rhythm or left atrial enlargement on electrocardiogram. However, the non-invasive techniques such as myocardial scintigraphy and echocardiography are more sensitive. Doppler echocardiography is an

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important non-invasive and an easily reproducible method of evaluating and follow-up of hypertensive's with diastolic dysfunction. Therefore, the present study was conducted to determine the prevalence of left ventricular diastolic dysfunction in patients with essential hypertension by echocardiography.

MATERIAL AND METHODS

In this cross sectional study, 50 consecutive newly detected or previously detected hypertensive patients with blood pressure (BP) more than 140/90 mm of Hg (JNC VII Stage I and II) at two or more recordings after an initial screening were included. Patients of hypertension with renal failure, valvular heart disease, co-existent ischemic heart disease, gross congestive cardiac failure, atrial fibrillation, hypertrophic obstructive cardiomyopathy, severe anemia, diabetes mellitusand on treatment with antihypertensive drugs were excluded from the study. The BP were measured with the mercury sphygmomanometer in the consulting room in sitting position after about 5–10 minutes of rest according to standard guidelines [6]. Those individuals with an average SBP greater than or equal to 140 mmHg and/or the DBP of greater than or equal to 90 mmHg on two or more separate hospital visits were considered to be hypertensive.

The study protocol was approved by the local Ethical Review Committee, and a written informed consent was obtained from all those that participated in the study. Complete history and physical examination along with routine hematological and biochemical investigations were done. Chest X-ray P-A view and ECG was done in all patients.Patients satisfying all the inclusion criteria were subjected to echocardiography. Echocardiography was done by a doctor trained and accredited by Indian Academy of Echocardiography on GE (Logiq 3) expert model no.AY-15 CUI. M-mode echocardiography was used to measure Left ventricular interior diameter at end systole –LVIDes, Left ventricular interior diameter at end diastole- LVIDed, Interventricular Septal Dimension end systole –IVSes, Interventricular Septal Dimension end diastole- IVSed, Left ventricular Posterior wall dimension end systole LVPWDes, Left ventricular Posterior wall dimension end diastole LVPWDed, End diastolic volume – EDV and End systolic volume-ESV.

Left ventricular mass was calculated according to CUBED formula (i.e. TECHHOLZ formula) as, Left ventricular Mass = $(IVS + LVIDed + LVPWD)^3 - (LVID)^3 \times 1.05 gm/cm^3$ (Where $1.05 gm/cm^3$ is specific gravity of muscle).

Left ventricular Hypertrophy was reported if Left ventricular mass was $>150 gm/cm^3$ for men and$>120 gm/cm^3$ for women. The ejection fraction (EF) in percentage was calculated using the formulae–E.F.= $(LVIDd^3 - LVIDs^3)/ LVIDd^3$ and E.F. (%)= EDV- ESV/ EDV ×100.

Evaluation of diastolic dysfunction was carried out by E/A ratio, Deceleration time and LA size. Ventricular diastolic function was measured by pulsed wave and continuous wave Doppler echocardiography. The mitral inflow velocities at the leaflet tips was used to assess LV diastolic dysfunction as this is the point at which mitral flow velocities are equal.

RESULTS

During the specified study period, 200 hypertensive patients were considered for participation in the study and assessment of left ventricular diastolic dysfunction. Of the 200 patients screened for the study, 50 patients had ischemic heart disease and 50 patients had diabetes mellitus and 50 patients had deranged renal function tests. These patients were studied clinically but excluded because they didn't satisfy the biochemical and other inclusion criteria.

The remaining 50 patients who satisfied all the inclusion criteria were enrolled and studied. The prevalence of left ventricular diastolic dysfunction in different age groups is 16.66%, 41.77%, 77.77% and 91.66% respectively. The difference between 35-45 age group and 66-75 age group was analyzed by applying Z test of proportion with a p value of <0.01 (highly significant statistically). Of the 50 patients studied, 25 were female and 25 were male. Of the 27 patients with left ventricular diastolic dysfunction 14 were female and 13 were male.

The duration of hypertension in the study population, ranged from ½ year to 10 years with mean duration of 3.06 years. 7 patients were newly detected hypertensive. In patients with left ventricular diastolic dysfunction, the duration of hypertension ranged from 1 year to 10 years with mean duration of 4.5 years. Only 1 patient with left ventricular diastolic dysfunction was newly detected hypertensive. Whereas, in patients of hypertension without left ventricular diastolic dysfunction, the duration of hypertension ranged from ½ year to 5 years with mean duration of 1.85 years and 6 patients were newly detected hypertensive.

Table 1: Demographic characteristics of study population

Variables	Patients with LVDD	Patients without LVDD	P-value
Mean Age (years)	59.66	47.69	< 0.01 (HS)
Stage of hypertension			
Stage I			
Systolic 140-159 mm of Hg	29	12	
Diastolic 90-99 mm of Hg			< 0.01 (HS)
Stage II			
Systolic > 160 mm of Hg	21	15	
Diastolic > 100 mm of Hg			
Blood pressure (mm Hg)			
Mean Systolic BP (mm Hg)	162.55	151.21	< 0.05 (S)
Mean Diastolic BP (mm Hg)	96	92	
Duration of hypertension (yrs)			
0-5	18	23	< 0.05(S)
6-10	09	00	

HS = Statistically Highly significant; S = Statistically Significant

In the present study, the systolic blood pressure of patients ranged from 130 mm of Hg to 220 mm of Hg. The average systolic blood pressure of patients participating in this study was 154.15 mm of Hg. The diastolic blood pressure of patients in the present study ranged from 84 mm of hg to 120 mm of Hg. The average diastolic blood pressure was 94.16 mm of Hg. The blood pressure recordings of patients in the study were staged according to the JNC VII recommendations. The average systolic blood pressure of patients with left ventricular diastolic dysfunction was 162.55 mm of Hg and ranged from 142 mm of Hg to 220 mm of Hg. The average diastolic blood pressure of patients with left ventricular diastolic dysfunction was 96 mm of Hg and ranged from 80 mm of Hg to 120mm of Hg. The average systolic blood pressure of patients without left ventricular diastolic dysfunction was 151.21 mm of Hg with a range from 130 to 170 mm of Hg. The average diastolic blood pressure of patients without left ventricular diastolic dysfunction was 92 mm of Hg with a range from 84 to 100 mm of Hg. The prevalence of left ventricular diastolic dysfunction in patients with stage I hypertension was 41.37%, while that in patients with stage II hypertension was 71.42%. All the patients selected for this study underwent echocardiographic evaluation by 2D, M-mode and Doppler echocardiography.

Table 2: Left ventricular indices derived from M mode echocardiography in study population

Sr. No.	Particulars	Patients with LVDD	Patients without LVDD
1.	Interventricular Septal Dimension (cm) (IVSed)	0.94	0.85
2.	Left Ventricular Posterior Wall Dimension (cm) (LVPWed)	0.99	0.87
3.	Left Ventricular Interior Diameter in End Diastole (cm)(LVIDed)	4.68	4.62
4.	Left Ventricular Interior Diameter in End Systole (cm)(LVIDes)	3.15	2.87

The interventricular septal dimension end diastole (IVSed) was recorded using M mode echocardiography. The mean IVSed in patients with left ventricular diastolic dysfunction was 0.94 cms. The means IVSed in patients without left ventricular diastolic dysfunction was 0.85 cms. Out of the 50 patients studied, 35 patients (70%) had evidence of left ventricular hypertrophy on M mode echocardiography. Thus, the prevalence of left ventricular hypertrophy in the study group was 46%.Out of the 35 patients with left ventricular hypertrophy on M mode echocardiography, 23 patients had left ventricular diastolic dysfunction on Doppler echocardiography. Thus, the prevalence of left ventricular diastolic dysfunction in patients with left ventricular hypertrophy was 65.71%. Out of the 27 patients, with left ventricular diastolic dysfunction on Doppler echocardiography, 23 patients had left ventricular hypertrophy on M mode echocardiography. Thus, the prevalence of left ventricular hypertrophy in patients of hypertension with left ventricular diastolic dysfunction was 85.18%. Patients were evaluated for the presence of regional wall motion abnormalities on 2D echocardiography. No patient included in the study showed regional wall motion abnormalities (RWMA).Volume in ml of the left ventricle at the end of diastole when maximally distended was recorded with help of M mode measurements. The EDV ranged from 48.83 ml to 196.12 ml. Mean End Diastolic Volume (EDV) in patients with left ventricular diastolic dysfunction was 107.63ml.Mean End Diastolic Volume

(EDV) in patients without left ventricular diastolic dysfunction was 99.98 ml. The volume in ml of the left ventricle at the end of systole when maximally contracted was recorded M Mode measurements. The ESV ranged from 10.40 ml to 77.30 ml. The mean End Systolic Volume (ESV) in patients with left ventricular diastolic dysfunction was 40.33 ml. The mean End Systolic Volume (ESV) in patients without left ventricular diastolic dysfunction was 28.81 ml. In the present study, the Ejection Fraction (EF) of patients ranged from 50% to 78.70%.The mean Ejection Fraction (EF) in patients with left ventricular diastolic dysfunction was 63.19%.The mean ejection fraction (EF) in patients without left ventricular diastolic dysfunction was 69.47%.

Table 3: Left ventricular indices derived on Doppler echocardiography in study population

Sr. No.	Particulars	Patients with LVDD	Patients without LVDD
1.	Peak Early Filling Velocity (in cm / sec) E	0.68	0.88
2.	Peak Atrial Filling Velocity (in cms/sec) A	0.97	0.67
3.	E/A ratio	0.71	1.36

The Peak Early Filling Velocity (E) and Peak Atrial Filling velocity (A) were measured at the mitral leaflet tips by Doppler echocardiography. The E/A ratio was calculated to assess the presence of left ventricular diastolic dysfunction. An E/A ratio less than 1.0 was considered indicative of the presence of left ventricular diastolic dysfunction.27 out of the 50 patients studied had an E/A ratio less than 1.0 suggesting the presence of left ventricular diastolic dysfunction. The E/A ratio in the study population ranged from 0.5 to 1.85 (Table 3) (Fig. 1). E wave deceleration time (EDT) was more than 200ms in 20 patients out of 27 patients having diastolic dysfunction. LA size is more than 4 cm in 12 out of 27 patients having left ventricular diastolic dysfunction.

DISCUSSION

Diastolic dysfunction as a concept in clinical cardiology is relatively new. The initial concepts of heart failure centered around the ability of the heart to maintain a forward flow by its pumping action; specifically, by expressing its contents. A decrease in the pumping action of the heart i.e., its systolic function was considered the defining characteristic of the heart failure state. A series of investigators have proved beyond any degree of doubt that the ability of the ventricle to actively relax and passively comply with filling of blood in diastole is as crucial to normal ventricular function as is its ability to contract and expel blood to the periphery in systole[7,8]. Furthermore, any failure in this crucial diastolic function of the heart can result in clinical features of the heart failure state in the presence of normal systolic function. Hypertensive heart disease is an important cause of left ventricular diastolic dysfunction[9].

Figure 1: Echocardiography and Color Doppler of 60 yrsold male patient (known hypertensive since 6 years) showing LVdiastolic dysfynction with E/A ratio 0.73

With advancing age, the prevalence of left, ventricular diastolic dysfunction increases. This is explained by the increased duration of arterial hypertension with advancing age and also the independent effects of aging on left ventricular relaxation. Li SY *et al*[10] also detailed the effects of aging on left ventricular diastolic dysfunction and pointed out that the increased incidence of impaired relaxation and increased passive stiffness was due to increased interstitial collagen content and decreased number of functioning myocytes that occur as part of the normal ageing process.

As the duration of the hypertensive state increased, prevalence of echocardiographic evidence of left ventricular diastolic dysfunction also increased. This is explained by the progressive nature of adaptive changes occurring in the left ventricular myocardium in

face of the increased afterload characteristic of the hypertensive state[9].

The prevalence of left ventricular diastolic dysfunction in patients with stage I hypertension was 41.37% while that in patients with stage II hypertension was 71.42%. It has been noted that as the stage of hypertension progressed, (i.e. the severity of hypertension increased) the prevalence of left ventricular diastolic dysfunction also increased. Also it was noted that patients with echocardiographic evidence of left ventricular diastolic dysfunction had higher systolic and diastolic blood pressure as compared to those individuals without left ventricular diastolic dysfunction. The findings from the present study correlate well with those of Schmieder RE and Misserli FH[11] who showed that LVH is found in nearly 90% of persons with severe hypertension. BreisbaltWM *et al*[12] studied the effects of long standing hypertension on left ventricular function and found that more significant increases in mean arterial pressure uncovered greater degrees of left ventricular dysfunction; a finding that correlates with the findings from the present study.

Celentano A *et al*[13] found that hypertensives with a higher pulse pressure had upto a two-fold higher prevalence of left ventricular hypertrophy and dysfunction but not independently of systolic blood pressure suggesting that systolic blood pressure is the explanatory link of the relation between pulse pressure and left ventricular hypertrophy/ dysfunction. Missault LH *et al*[14] concluded that parameters of left ventricular hypertrophy are more closely related to systolic than to diastolic blood pressure and that night time blood pressure correlates better with left ventricular mass than day time blood pressure.

In the present study, the presence of left ventricular hypertrophy was assessed on M mode echocardiography. Out of the 50 patients studied, 35 patients (70%) had evidence of left ventricular hypertrophy. Thus the prevalence of left ventricular hypertrophy in the study group was 70%.Out of these 35 patients, 23 patients had left ventricular diastolic dysfunction on Doppler echocardiography. Thus, the prevalence of left ventricular diastolic dysfunction in patients with left ventricular hypertrophy was 65.71%.

Out of the 27 patients with left ventricular diastolic dysfunction on Doppler echocardiography, 23 patients had left ventricular hypertrophy on M mode echocardiography. Thus, the prevalence of left ventricular hypertrophy in patients of hypertension with left ventricular diastolic dysfunction was 85.88%. Dipette D J and Frohlich E[15] reported diastolic dysfunction manifested by reduced ventricular dispensability of a hypertrophied left ventricle in patients of hypertension to be an early characteristic of the hypertensive heart disease. Pavulopoulos H *et al*[9] reported that left ventricular diastolic dysfunction appears early in **hypertensive disease,** before the onset **of** abnormal remodeling or LV hypertrophy. With progression **of** the remodeling process **an**d the adv**an**ce **of** LVH, **diastolic** function progressively deteriorates. Rusconi C and coworkers[16] reported that in a large group of hypertensive patients with normal left ventricular systolic function, prevalence of left ventricular diastolic dysfunction as assessed by Doppler echocardiography stood at 51%. This finding correlates well with the findings from the present study.

In Indian scenario, study done by Lele RD and coworkers[17] have studied 121 patients and found isolated diastolic dysfunction in 66% patients by myocardial perfusion imaging. This percentage is very close to the present study.

The prevalence of left ventricular diastolic dysfunction documented by echocardiography in the present study was 54%.These individuals comprised a heterogeneous group and included those with and without left ventricular hypertrophy.

The prevalence of left ventricular hypertrophy in the present study was 70%. 85.88% of individuals in the study with left ventricular hypertrophy also had left ventricular diastolic dysfunction on Doppler echocardiography; with an E/A ratio<1.Thus left ventricular diastolic dysfunction is an almost inevitable accompaniment in patients who develop left ventricular hypertrophy.

In patients with left ventricular diastolic dysfunction on echocardiography, the prevalence of left ventricular hypertrophy was 65.71%. Thus, left ventricular hypertrophy is an important risk factor for development of left ventricular diastolic dysfunction. The 34.28% of patients with left ventricular diastolic dysfunction but without left ventricular hypertrophy are a strong pointer to the fact that left ventricular diastolic dysfunction appears prior to the establishment of left ventricular hypertrophy and is an early indicator of cardiac involvement in hypertensive patients. Early recognition of diastolic dysfunction, especially in hypertensive patients, provides an opportunity to prevent progression to heart failure.

REFERENCES

1. WHO. Preventing chronic diseases: A vital investment. 2005. [accessed May 18, 2017]. http://www.who.int/chp /chronic_disease_report/full_report.pdf.
2. Dosh SA.The treatment of adults with essential hypertension.J Fam Pract 2002 Jan;51(1):74-80.
3. Little WC. Heart Failure With A Normal Left Ventricular Ejection Fraction: Diastolic Heart Failure. Transactions of the

American Clinical and Climatological Association 2008;119:93-102.
4. Zile M, Brutsaert D. New concepts in diastolic dysfunction and diastolic heart failure: I. Diagnosis, prognosis, and measurements of diastolic function. Circulation 2002;105:1387.
5. Nishimura RA, Tajik AJ. Evaluation of diastolic filing of left ventricle in Health and Disease: Doppler echocardiography is the Clinicians' Rosetta stone. J Am CollCardiol1997;30:181–188.
6. American Society of Hypertension, author. Recommendations for routine blood pressure measurement by indirect cuff Sphygmomanometer. Am J Hypertens1992;5:207–209.
7. Hamlin SK, Villars PS, Kanusky JT, Shaw AD. Role of diastole in left ventricular function, II: diagnosis and treatment.Am J Crit Care 2004;13:453-466.
8. Little WC, Downes TR. Clinicalevaluation of leftventriculardiastolic performance.ProgCardiovasc Dis 1990;32(4):273-90.
9. Pavlopoulos H, Grapsa J, Stefanadi E, Kamperidis V, Philippou E, Dawson D, Nihoyannopoulos P. The evolution of diastolic dysfunction in the hypertensive disease.Eur J Echocardiogr 2008;9(6):772-8.
10. Li SY, Du M, Dolence EK, Fang CX, Mayer GE, Ceylan-Isik AF, LaCour KH, *et al*. Aging induces cardiac diastolicdys function, oxidativestress, accumulation of advanced glycation end products and protein modification. Aging Cell 2005;4(2):57-64.
11. RE Schmieder, FH Messerli. Hypertension and the heart. J Human Hypertension 2000;14:597–604.
12. Breisblatt WM, Wolf CJ, McElhinny B, Salerni R, Smith VE. Comparison of ambulatory left ventricular ejection fraction and blood pressure in systemic hypertension in patients with and without increased left ventricular mass. Am J Cardiol1991;67(7):597-603.
13. Celentano A, Palmieri V, Di Palma Esposito N, Pietropaolo I, Arezzi E, Mureddu GF, de Simone G.Relations of pulse pressure and other components of blood pressure to preclinical echocardiographic abnormalities. J hypertension 2002;20(3):531-537.
14. Missault LH, De Buyzere ML, De Baequer DD,Duprez DD, Clement DL. Relationship between left ventricular mass and blood pressure in treated hypertension. J Human Hypertension 2002;16(1):61-66.
15. Dipette DJ, Frohlich ED. Cardiac involvement in Hypertension. Am J Cardiol1988;61(16):67H-72H.
16. Rusconi C, Sabatini T, Faggiano P. Prevalence of isolated left ventricular diastolic dysfunction in hypertension as assessed by combined transmitral and pulmonary vein flow Doppler study.Am J Cardiol2001;87(3):357-360.
17. RD Lele, KarunaLuthra, Yogini Sawant. Assessment of Diastolic Heart Function – Experience with 16-gated Myocardial Perfusion SPECT. JAPI 2008;16:763-767.

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