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A Study on Evaluation of Relationship between Left Atrial Volume and Diastolic Dysfunction in Bangladeshi Patients

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Abstract

***Background*:** An increase in the left atrial volume index (LAVI) has been recognized as an important indicator of left ventricular (LV) diastolic dysfunction (DD), which is considered a significant risk factor for cardiovascular events. The left atrium plays a crucial role in maintaining efficient cardiac function by facilitating proper blood flow between the pulmonary veins and the left ventricle during diastole. ***Objective*:** In this study our main goal is to evaluate the relationship between Left Atrial Volume and Diastolic Dysfunction in 500 Bangladeshi Patients. ***Method*:** From January 2022 to January 2023, researchers at a tertiary hospital in Bangladesh analyzed data from 500 patients in need of a transthoracic echo in the cardiology department. Patients were people aged 20 to 86 with a history free of atrial or ventricular arrhythmias, pacemaker usage, valvular disease (other than minor), or congenital cardiopathy who presented with sinus rhythm. Forty-five people were left out because their tests were either too limited to assess mitral diastolic flow (n = 35) or too limited to assess left atrial volume index (n = 10). Five hundred patients were used as the study's final sample size. ***Results*:** The average age and proportion of men in the DD groups were both greater than in the normal function group. The DD groups had more left ventricular mass than the controls. Only in the group with ventricular filling limitation pattern (grade III DD), was the ejection fraction significantly decreased. LAVI and dimensions both rose as DD severity increased, from 21 4.2 mL/m2 in grade I to 26.1 7.5 mL/m2 in grade II to 50.4 2.8 mL/m2 in grade III (p 0.001). In addition, the grade I DD groups (altered relaxation) showed a relative decrease in the E-wave and the E/A ratio, and an increase in the mitral deceleration time, when compared to the normal diastolic function group; the opposite was seen in the group with grade III DD (restrictive pattern). All DD subtypes had weaker e' waves compared to those with normal diastolic function. As DD progressed, a rise in the E/e' ratio was seen. LAVI was positively correlated with age, left ventricular (LV) diastolic and systolic volumes, LV wall relative thickness, LV mass indexed to height raised to the 2.7th power, and E/e' ratio (all p 0.01). There was a statistically significant negative relationship between left atrial volume index and left ventricular ejection fraction, as well as between the e' wave and the septal mitral anulus. ***Conclusion*:** According to this study in a Bangladeshi population, DD contributes to left atrial remodelling, and a rise in LAVI is an indicator of DD severity. In this cohort with preserved or slightly reduced mean ejection fraction and no substantial valvular heart disease, LAVI increase determinants are related to age, left ventricular hypertrophy, higher filling pressure, and impaired LV systolic performance.

Keywords: Left Atrial Volume (LAV), Left Atrial Volume Index (LAVI) Diastolic Dysfunction (DD).

INTRODUCTION

Diastolic dysfunction (DD) is a major prognostic indicator for many different cardiac disorders, and it is more common in the elderly. It has been associated to the onset of atrial fibrillation and is a leading cause of heart failure. Approximately 25% to 30% of the general population over the age of 45 have asymptomatic DD. Heart failure with preserved systolic function (ejection fraction >50%) accounts for 51% of all heart failure patients, and symptomatic DD may develop in combination with left ventricular (LV) systolic dysfunction or as a cause of such [1-5].

Pulsatile Doppler measurement of mitral diastolic flow and tissue Doppler studies of mitral ring velocity has been used in clinical practice to detect DD in a straightforward and noninvasive method [6, 7].

More reliable than the basic anteroposterior diameter acquired from M-mode echo3, left atrial volume indexed by body surface (LAVI) calculated using bidimensional echo has recently been suggested for diagnosing left atrial dilatation. It has been suggested that LAVI may be used to assess the severity and duration of DD as well as anticipate cardiac events such atrial fibrillation, heart failure, and embolic stroke. It has also been graded using the LV criteria and found to be DD level.

Although there are international researches linking LAVI elevation with DD severity, no large-scale investigations have been conducted in the Bangladeshi community [8].

OBJECTIVE

To assess the connection between LAVI and the various DD degrees in a group of outpatients with intact or slightly impaired systolic function who were referred to ECHO in a tertiary hospital in Bangladesh.

METHODOLOGY

Between January 2022 and January 2023, researchers at a tertiary hospital in Bangladesh examined 500 individuals for whom a transthoracic echo had been prescribed as part of a cross-sectional study. Patients were people aged 20 to 86 with a history free of atrial or ventricular arrhythmias, pacemaker usage, valvular disease (other than minor), or congenital cardiopathy who presented with sinus rhythm. Forty-five people were left out because their tests were either too limited to assess mitral diastolic flow (n = 35) or too limited to assess left atrial volume index (n = 10). Five hundred patients were used as the study's final sample size.

The patient's vitals were taken alongside the echocardiographic reading, including their height, weight, body mass index, heart rate, and blood pressure. History of hypertension, or systolic blood pressure 140 mmHg and/or diastolic blood pressure 90 mmHg on at least two separate occasions, was used to diagnose arterial hypertension. Patients with fasting glucose levels more than 125 mg/dl or those who were using oral hypoglycemic drugs and/or insulin were diagnosed with diabetes mellitus. If your cholesterol levels were above 200 mg/dl and/or your LDL cholesterol was over 130 mg/dl, then you had dyslipidemia and needed treatment with hypolipidemic drugs. Participants who used tobacco products over the course of the research were classified as smokers. Obesity was defined as a body mass index more than 30. Patients with risk factors were diagnosed with coronary artery disease based on their medical history, electrocardiographic data, or the appearance of segmental contractile failure on an echocardiogram.

Pearson's correlation coefficient was used to measure the simplicity of correlations between LAVI and clinical and echocardiographic variables. The variables with statistically significant partial correlations were included in the model of multivariate linear regression used to find independent predictors of LAVI rise. Two-tailed tests with a type I error of 5% (p 0.05) were used to examine the statistical hypotheses.

RESULTS

Table-1 shows demographic status of the patients where mean age and male percentage were higher in the DD groups as compared to the normal function group. The following table is given below in detail:

Table 1: Demographic status of the patients

Variables	**Normal, n=331**	**DD grade I, n=111**	**DD grade II, n=49**	**DD grade III, n=9**
Mean Age	47.1 ± 13.8	64.4 ± 10.6*	60.2 ± 10.9 *	70.6 ± 15.3
BMI	26.4 ± 4.9	29.1 ± 4.8	29.9 ± 5	26.2 ± 5.7
Gender	**Normal, n=331**	**DD grade I, n=111**	**DD grade II, n=49**	**DD grade III, n=9**
Male	160, 48.34%	68, 61.26%	32, 65.315	5, 55.55%
Female	169, 51.66%	43, 38.74%	17, 34.69%	4, 44.45%

Table-2 shows clinical characteristics of the normal diastolic function group and the diastolic dysfunction groups where left ventricular mass were higher in the DD groups as compared to the normal function group. The ejection fraction was markedly reduced only in the grade III DD group (ventricular filling restriction pattern). The following table is given below in detail:

Table 2: Clinical characteristics of the normal diastolic function group and the diastolic dysfunction groups

Variables	**Normal, n=331**	**DD grade I, n=111**	**DD grade II, n=49**	**DD grade III, n=9**
Arterial hypertension (%)	144 (43.50%)	87 (78.37%)*	42 (85.71%)*	5 (55.6%)
Diabetes Mellitus (%)	11 (3.32%)	16 (14.4%)	13 (26.5%)	1 (11.1%)
Obesity (%)	57 (17.2%)	44 (39.6%)	21 (42.9%)	2 (22.2%)
LVH (%)	112 (33.8%)	83 (75.5%)*	45 (71.4%)*	9 (100%)
EF%	70.6 ± 5.5	69.3 ± 6.4	68.9± 7.4	43.7 ± 15.9
LV mass	182.3 ± 64.8	249 ± 78.2**	261.5 ± 75.2**	318.4 ± 90
LV mass/$h^{2,7}$	47.5 ± 17.8	67.5 ± 20.1**	65.1 ± 18.4**	86.2 ± 26.8*

DD: diastolic dysfunction LVH: left ventricular hypertrophy; BMI: body mass index; EF: ejection fraction; LV: left ventricle

Table-3 revealed the distribution of the patients according to Echocardiographic variables and DD grades where LAVI and dimensions progressively increased with DD grade increase: 21 ± 4.2 mL/m2, 26.1 ± 7.5mL/m2 (grade I), 33.4 ± 4.6mL/m2 (grade II), 50.4 ± 2.8mL/m2 (grade III) ($p < 0.001$). Plus, as expected, there was a relative decrease of the E-wave and E/A ratio, and an increase of the mitral deceleration time in the grade I DD groups (altered relaxation) in comparison to the group with normal diastolic function; the opposite was observed in the group with grade III DD (restrictive pattern). The e' wave was significantly smaller in all DD grades, in comparison to the group with preserved diastolic function. Progressive increase of the E/e' ratio was observed with worsening DD. The following table is given below in detail:

Table 3: Distribution of the patients according to Echocardiographic variables and DD grades

Structure	**Normal, n=331**	**DD grade I, n=111**	**DD grade II, n=49**	**DD grade III, n=9**
LA (mm)	3.4 ± 0.4	3.6 ± 0.4*	4.1 ± 0.4	5.0 ± 0.6
LAV (mL)	39.3 ± 9.3	48.2 ± 14.7*	64.7 ± 11	88.9 ±12.5
LAVI (mL/m²)	21.6 ± 4.2	26.1 ± 7.5*	33.4 ± 4.6	50.4 ± 2.8
LVDD (mm)	5.0 ± 0.5	5.2 ± 0.5	5.4 ± 0.8	6.5 ± 1.2
LVSD (mm)	3.1 ± 2.1	3.2 ± 0.5	3.3 ± 0.6	5.0 ± 1.4
IVS (mm)	1.0 ± 0.9	1.1 ± 0.2	1.2 ± 0.3	1.9± 2.7
LVPW (mm)	1.0 ± 0.9	1.2 ± 1.1	1.1 ± 0.1	2.0 ± 2.9
RWT	0.36 ± 0.1	0.42 ± 0.1	0.42 ± 0.1	0.32 ± 0.1
Mitral Doppler	**Normal, n=331**	**DD grade I, n=111**	**DD grade II, n=49**	**DD grade III, n=9**
height="26">E (m/s)	79 ± 18	58.8 ± 11.6**	82.7 ± 13.9	98.6 ± 32.1
A (m/s)	64.7 ± 17	87.3 ± 18.4	74.3 ± 18	50.9 ± 16
E/A	1.29 ± 0.5	1.3 ± 7.4**	1.16 ± 0.2	2.1 ± 0.8
DT (ms)	156 ± 25	226 ± 34**	172 ± 20	137 ± 12
Tissue Doppler	**Normal, n=331**	**DD grade I, n=111**	**DD grade II, n=49**	**DD grade III, n=9**
e' (m/s)	11.5 ± 4.1	7.4 ± 7.1**	7.2 ± 1**	5.9 ± 1.2
E/e'	7.1 ± 2	8.8 ± 2.1*	11.3 ± 2.5**	16.1 ± 2.6

Here DD: diastolic dysfunction; LA: left atrium; LAV: left atrial volume; LAVI: left atrial volume; LVDD: left ventricle diastolic diameter; LVSD: left ventricle systolic diameter; IVS: intraventricular septum; LVPW: left ventricle posterior wall; RWT: relative wall thickness E: mitral flow protodiastolic velocity; A: mitral flow telediastolic velocity; E/A: ratio between E and A waves; e: septal mitral anulus protodiastolic velocity; E/e': ratio between E and e' waves.

In fgure-1 explains Left atrial volume index and different diastolic dysfunction grades where for grade I DD, we found 60.45 sensitivity and 74.6¨% specificity for LAVI = 24 mL/m2. The curve showed excellent performance for identification of grade II DD (AUC = 0.970) with LAVI≥ 27,9 mL/m2 showing 98% sensitivity and 90.6% specificity. For grade III DD, LAVI≥ 40 mL/m2 was 100% sensible and specific.

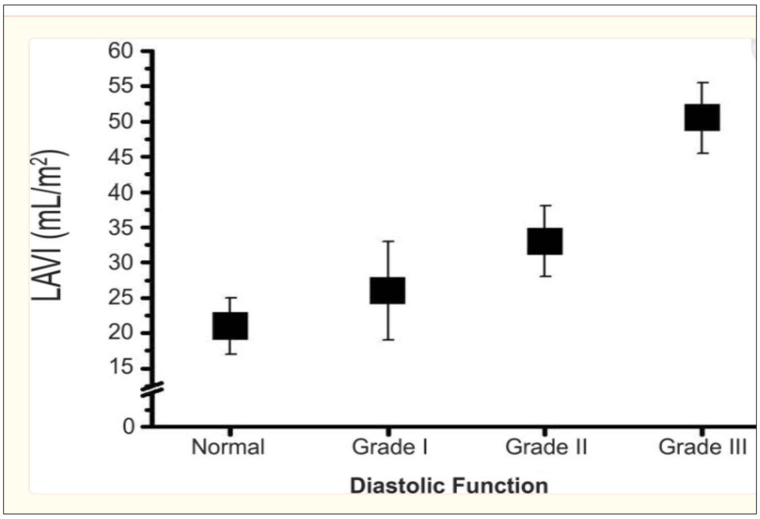

Figure 1: ROC curve analysis of Left atrial volume index and different diastolic dysfunction grades
Source by: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3998172/ [2]

Table-4 indicates the results of the univariate analysis of LAVI and the other clinical and echocardiographic variables where there was a significant and direct correlation of LAVI and age, LV diastolic and systolic volumes, LV wall relative thickness, LV mass indexed to height raised to 2.7

power and E/e' ratio ($p < 0.01$). There was an inverse and significant correlation between LAVI and LV ejection fraction; the same occurred for e' wave and septal mitral anulus. The following table is given below in detail:

Table 4: Univariate analysis of LAVI and the other clinical and echocardiographic variables

Variable	r	P
Age	0.365**	< 0.001
BMI	0.072	0.155
LA	0.611**	< 0.001
LVDD	0.381**	< 0.001
LVSD	0.145**	0.001
RWT	0.160*	< 0.001
LV mass	0.441**	< 0.001
LV mass/ht$^{2.7}$	0.454**	< 0.001
LV ejection fraction	-0.297**	< 0.001
E	0.050	0.267
A	0.157**	< 0.001
E/A	-0.020	0.655
e'	-0.239**	< 0.001
E/e'	0.470**	< 0.001

BMI: body mass index; LA: left atrial anteroposterior diameter; LV: left ventricle; LVDD: left ventricle diastolic diameter; LVSD: left ventricle systolic diameter; RWT: relative wall thickness; E: mitral flow protodiastolic velocity; A: mitral flow telediastolic velocity; E/A: ratio between E and A waves; e: septal mitral anulus protodiastolic velocity; E/e': ratio between E and e' waves.

DISCUSSION

The direct influence of DD on left atrial remodelling was already known, but we confirmed this with our finding [2]. In addition to age, LV hypertrophy, LV dysfunction, and an elevated E/e' ratio, these results lend credence to the idea that left atrial dilation is a prognostic marker for cardiovascular events (as shown by atrial fibrillation and heart failure) [2].

Several pathologies of the heart may cause left atrial remodeling due to volumetric or pressoric hemodynamic stress. Left atrial remodeling also involves DD as an extra component. Alterations in the interaction between actin and myosin, increased collagen deposition, and changes in cardiac viscoelastic characteristics all contribute to abnormal LV relaxation and lower LV compliance in DD [9, 10].

There is an increase in the A wave in mitral Doppler during the early stages of DD (grade I), but no glaring anatomical anomalies in the left atrium. This is due to the increasing involvement of left atrial active contraction, which becomes more powerful in trying to overcome the relaxation issue. This compensatory process breaks down as the condition advances, causing the atrium to restructure and reducing the heart's ability to fill effectively. Left atrial pressure increases to keep the left ventricle properly filled, leading to a stretch in the atrial myocardium and a widening of the atrial chambers. Consequently, an increase in LAVI indicates that the left atrium has been repeatedly subjected to severe DD and/or high LV filling pressures.

In this study, individuals with normal diastolic function had a mean LAVI of 21.6 4.2mL/m2. This number is quite close to the typical range of 20.6-21.7 mL/m2 seen in the general population [8-10].

We have also calculated very precise LAVI cutoff values associated with the letter grades ll and DD. Our research, Pritchett *et al.*, [11] study with 2042 patients, and Tsang *et al.*, [12] study all found that LAVI had excellent sensitivity and specificity for detecting moderate (II) and severe (II) grade DD; however, their results were lower than ours. The variations might be due to changes in case selection.

These results highlight the importance of using this index as an adjunct to the other parameters of mitral diastolic flow pattern for DD analysis in routine clinical settings. Remember that the pressoric gradients that characterize the hemodynamic moment are expressed by the pulsatile Doppler components in the mitral flow. However, increases in pressure over time alter the left atrium's structure. Grad II dysfunction, also known as the so-called pseudo normal left ventricular filling pattern, may be easier to identify in the latter stages of DD when combined with LAVI assessment and pulsed Doppler study of transmitral flow and mitral annulus velocities [11, 12].

We used multivariate analysis to identify age, left ventricular hypertrophy (left ventricular mass and relative wall thickness), the E/e' ratio, and the LV ejection percent as the predictors of LAVI elevation in this group. Age is correlated with a more severe DD presentation, and the prevalence of VE DD increases with age. Another factor connected to DD13 is LV hypertrophy. Grades II and III DD presentations, which are associated with systolic dysfunction and left ventricular remodeling with increased filling pressures, may have benefited more from these characteristics.

CONCLUSION

This research in Bangladeshi subjects suggests that DD causes left atrial remodeling and that an increase in left atrial volume index (LAVI) is a marker for the severity of DD. Age, left ventricular hypertrophy, greater filling pressure, and worse LV systolic performance are connected to LAVI increase determinants in this population with intact or slightly decreased mean ejection fraction and no major valvular heart disease.

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