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The Relationship between Left Atrial Volume and Diastolic Dysfunction in 500 Bangladeshi Patients

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Abstract **Original Research Article**

Background: An increase in the left atrial volume index (LAVI) has been linked to left ventricular (LV) diastolic dysfunction (DD), a risk factor for cardiovascular events. ***Objective:*** In this study our main goal is to evaluate the relationship between Left Atrial Volume and Diastolic Dysfunction in 500 Bangladeshi Patients. ***Method:*** This cross sectional study was carried out at tertiary hospital from January 2021 to January 2022 among 500 Bangladeshi patients in whom a transthoracic echo was indicated were studied at cardiology department. The eligible patients were adults aged 20 to 86 years, who presented sinus rhythm and had no history of atrial or ventricular arrhythmia, pacemaker use, valvular disease (other than mild) or congenital cardiopathy. Forty five individuals were excluded since their exams were not adequate for analyzing mitral diastolic flow (n = 35) or LAVI (n = 10). The 500 remaining patients comprised the final sample for this study. ***Results:*** Mean age and male percentage were higher in the DD groups as compared to the normal function group 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).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. 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. ***Conclusion:*** According to this study in a Bangladeshi population, DD contributes to left atrial remodeling, 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 quite frequent, particularly in the elderly, and is regarded as a significant prognostic indication for a variety of cardiac diseases [1]. It is a major cause of heart failure and has been linked to the development of atrial fibrillation [2]. Asymptomatic DD affects around 25% to 30% of people over the age of 45 in the general population [3]. Symptomatic DD can develop in conjunction with left ventricular (LV) systolic dysfunction or as a cause of heart failure with maintained systolic function (ejection fraction >50%), which accounts for 51% of all heart failure cases [4, 5].

In medical practice, DD has been found in a simple and harmless manner using eco-Doppler-cardiography (Eco) [6] and is characterized by pulsatile Doppler measurement of mitral diastolic flow and tissue Doppler research of mitral ring velocity [7].

Recently, left article volume indexed by body surface (LAVI) determined by bidimensional echo was proposed as a more reliable index for detecting left atrial dilatation than simple anteroposterior diameter derived from M-mode echo [3]. LAVI has been proposed as a predictor of cardiac events such as atrial fibrillation, heart failure, and embolic stroke[2], as well as a measure of the severity and duration of DD. Furthermore, it has been evaluated using the DD grade and LV criterion.

Although some studies performed abroad associate LAVI increase to DD severity [2], we do not have exclusively national data on this subject in a great number of patients from a Bangladeshi population.

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

This cross sectional study was carried out at tertiary hospital from January 2021 to January 2022 among 500 Bangladeshi patients in whom a transthoracic echo was indicated were studied at cardiology department. The eligible patients were adults aged 20 to 86 years, who presented sinus rhythm and had no history of atrial or ventricular arrhythmia, pacemaker use, valvular disease (other than mild) or congenital cardiopathy. Forty five individuals were excluded since their exams were not adequate for analyzing mitral diastolic flow (n = 35) or LAVI (n = 10). The 500 remaining patients comprised the final sample for this study.

Height, weight, BMI, heart rate and blood pressure were measured on the same day of the echocardiographic exam. Arterial hypertension was defined by the history, systolic levels ≥ 140 mmHg and/or diastolic levels ≥ 90 mmHg on at least two occasions. The diagnosis of diabetes mellitus was based on fasting glucose levels > 125 mg/dl or oral hypoglycemic drug and/or insulin use. Dyslipidemia was defined as total cholesterol levels > 200 mg/dl and/or LDL cholesterol > 130 mg/dl or hypolipidemic agents. Individuals who smoked at time the study was performed were considered smokers. Body mass index ≥ 30 was considered indicative of obesity. Coronary artery disease was defined by medical history, electrocardiographic data or presence of segmental contractile dysfunction at the echocardiogram in individuals with risk factors.

Simple associations between LAVI and clinical and echocardiographic variables were estimated by Pearson's correlation coefficient. Multivariate linear regression was done to determine independent predictors of LAVI increase, including in the model only variables with statistically significant partial correlations. Statistical hypotheses were tested in two-tailed tests with 5% type I error ($p < 0.05$).

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.

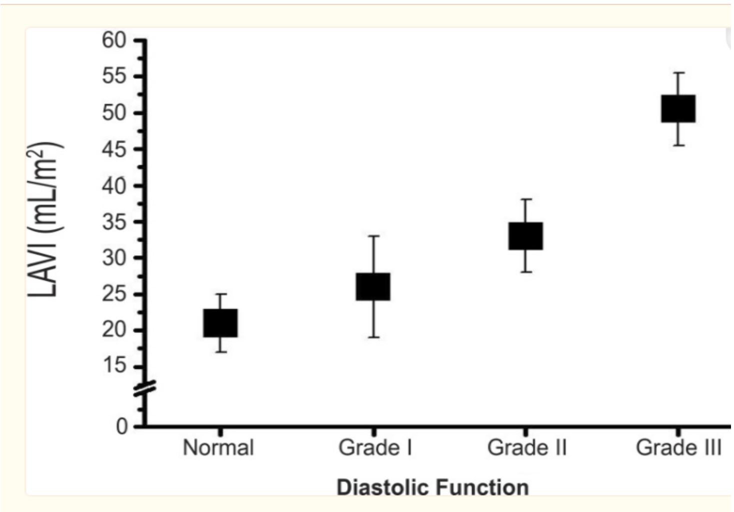

Figure-1: ROC curve analysis of Left atrial volume index and different diastolic dysfunction grades
Source by: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3998172/ [2]

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

Our significant discovery was the confirmation of the previously established direct impact of DD on left atrial remodelling [2]. These findings support the concept of left atrial dilation as a prognostic marker for cardiovascular events (as demonstrated by atrial fibrillation and heart failure) [2], in addition to other risk factors traditionally associated with poor prognosis (age, LV hypertrophy, LV dysfunction, and increased E/e' ratio).

Left atrial remodeling can occur as a result of volumetric or pressoric hemodynamic stress in a variety of heart disorders. DD is an additional factor in left atrial remodeling. In DD, aberrant LV relaxation and decreased LV compliance occur as a result of alterations in the interplay between actin and myosin, increased collagen deposition, and changes in cardiac viscoelastic properties [10].

During the early DD phases (grade I), there is simply increased participation of left atrial active contraction, which becomes more forceful in order to overcome the relaxation problem, resulting in an increase in A wave in mitral Doppler, but no obvious structural abnormalities in this chamber. As the disease progresses, this compensatory mechanism fails, compromising overall atrial filling capacity and leading to atrial remodeling. To maintain proper left ventricular filling, left atrial pressure rises, causing increased tension at the atrial walls, chamber dilatation, and atrial myocardial stretching. LAVI rise therefore implies persistent left atrial exposure to high LV filling pressures and DD severity [2].

In the current investigation, the mean LAVI value in people with normal diastolic function was 21.6 ± 4.2mL/m2. This result is extremely close to that reported in normal people, who have values ranging from 20 6 to 21 7 mL/m [2, 8, 9].

We have also determined with great precision LAVI cutoff values linked with grades ll and DD. LAVI had high sensitivity and specificity in the detection of moderate (II) and severe (II) grade DD in our investigation, as well as Pritchett *et al.*, [11] 's study, which comprised 2042 patients, and Tsang *et al.*, [2] 's study, however the values were lower than ours. Disparities in case selection may explain the differences.

These findings emphasize the use of this index in everyday practice as a supplement to the other factors of mitral diastolic flow pattern for DD analysis. It is important to recall that pulsatile Doppler components in mitral flow express pressoric gradients that represent the hemodynamic moment. Pressure increases over time, on the other hand, create structural changes in the left atrium. Thus, pulsed Doppler analysis of transmitral flow and mitral annulus velocities in conjunction with LAVI measurement might help distinguish the most advanced phases of DD, particularly grade II dysfunction or the so-called pseudo normal left ventricle filling pattern [12].

Using multivariate analysis, we discovered that age, LV hypertrophy (left ventricular mass and relative wall thickness), E/e' ratio, and LV ejection fraction are the determinants of LAVI rise in this cohort. The incidence of VE DD rises with age, and advanced age is related with more severe DD presentation [12], validating this observation. LV hypertrophy is another component that has been linked to DD [13]. These factors may have had a larger role in the most severe DD presentations (grades II and III), which are linked with systolic dysfunction and left ventricular remodeling with higher filling pressures.

Conclusion

According to this study in a Bangladeshi population, DD contributes to left atrial remodeling, 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.

References

1. Grossman, W. (2000). Defining diastolic dysfunction. *Circulation*, 101(17), 2020–2021.
2. Aouar, L. M. M. E., Meyerfreud, D., Magalhães, P., Rodrigues, S. L., Baldo, M. P., Brasil, Y., ... & Campos Filho, O. (2013). Relationship between left atrial volume and diastolic dysfunction in 500 Brazilian patients. *Arquivos brasileiros de cardiologia*, *101*, 52-58.
3. Lester, S. J., Tajik, A. J., Nishimura, R. A., Oh, J. K., Khandheria, B. K., & Seward, J. B. (2008). Unlocking the mysteries of diastolic function: deciphering the Rosetta Stone 10 years later. *Journal of the American College of Cardiology*, *51*(7), 679-689.
4. Gottdiener, J. S., McClelland, R. L., Marshall, R., Shemanski, L., Furberg, C. D., Kitzman, D. W., ... & Manolio, T. A. (2002). Outcome of congestive heart failure in elderly persons: influence of left ventricular systolic function: the Cardiovascular Health Study. *Annals of internal medicine*, *137*(8), 631-639.
5. Vasan, R. S., Larson, ScD, M. G., Benjamin, E. J., Evans, J. C., Reiss, C. K., & Levy, D. (1999). Congestive heart failure in subjects with normal versus reduced left ventricular ejection fraction: prevalence and mortality in a population-based cohort. *Journal of the American College of Cardiology*, *33*(7), 1948-1955.
6. Paulus, W. J., Tschöpe, C., Sanderson, J. E., Rusconi, C., Flachskampf, F. A., Rademakers, F. E., ... & Brutsaert, D. L. (2007). How to diagnose diastolic heart failure: a consensus statement on the diagnosis of heart failure with normal left ventricular ejection fraction by the Heart Failure and Echocardiography Associations of the European Society of Cardiology. *European heart journal*, *28*(20), 2539-2550.
7. Nagueh, S. F., Appleton, C. P., Gillebert, T. C., Marino, P. N., Oh, J. K., Smiseth, O. A., ... & Evangelisa, A. (2009). Recommendations for the evaluation of left ventricular diastolic function by echocardiography. *European Journal of Echocardiography*, *10*(2), 165-193.
8. Lang, R. M., Bierig, M., Devereux, R. B., Flachskampf, F. A., Foster, E., … & Pellikka, P. A. (2005). Chamber Quantification Writing Group. American Society of Echocardiography's Guidelines and Standards Committee. European Association of Echocardiography Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. *J Am Soc Echocardiogr*, 18(12), 1440–1463.
9. Ujino, K., Barnes, M. E., Cha, S. S., Langins, A. P., Bailey, K. R., Seward, J. B., & Tsang, T. S. (2006). Two-dimensional echocardiographic methods for assessment of left atrial volume. *The American journal of cardiology*, *98*(9), 1185-1188.
10. Dent, C. L., Bowman, A. W., Scott, M. J., Allen, J. S., Lisauskas, J. B., Janif, M., ... & Kovács, S. J. (2001). Echocardiographic characterization of fundamental mechanisms of abnormal diastolic filling in diabetic rats with a parameterized diastolic filling formalism. *Journal of the American Society of Echocardiography*, *14*(12), 1166-1172.
11. Pritchett, A. M., Mahoney, D. W., Jacobsen, S. J., Rodeheffer, R. J., Karon, B. L., & Redfield, M. M. (2005). Diastolic dysfunction and left atrial volume: a population-based study. *Journal of the American College of Cardiology*, *45*(1), 87-92.
12. Teo, S. G., Yang, H., Chai, P., & Yeo, T. C. (2010). Impact of left ventricular diastolic dysfunction on left atrial volume and function: a volumetric analysis. *European Journal of Echocardiography*, *11*(1), 38-43.