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ORIGINAL ARTICLE

LEFT ATRIAL VOLUME INDEX (LAVI) IN THE EVALUATION OF LEFT VENTRICULAR DIASTOLIC DYSFUNCTION

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ABSTRACT: Although cardiac performance is traditionally focused on Ejection fraction an index of systolic function, diastolic function has been found to play an important role in morbidity and mortality. Diastolic heart failure constitutes about 20- 40% admissions of heart failure. Left atrium is directly exposed to LV pressures in diastole. Chronic sustained elevation of elevated diastolic filling pressures result in left atrial remodeling resulting in its enlargement. Traditionally left atrial size is determined from the parasternal long axis view at end systole. However the left atrial volume is a better measure of LA size and provides better prognostic value. The influence of body surface area is corrected by dividing LA volume by body surface area to get LA volume index (LAVI). The normal value for all age groups is 22 ± 6 ml/m.[1] **AIM:** To measure the left atrial volume and diastolic function in 60 subjects and to study the correlation between left atrial volume and diastolic dysfunction **METHODS:** 60 subjects (40 with diastolic dysfunction and 20 controls) referred to the echocardiography were studied. All subjects underwent trans thoracic echocardiography and Doppler imaging Diastolic filling was categorized as normal (grade 0) impaired relaxation (grade 1), pseudo normal pattern (grade 2), restrictive filling (grade 3). LA volume is measured by biplane area length method and indexed to BSA (LAVI) Results: Among diastolic dysfunction group, 25(62.5%) had Grade 1 diastolic dysfunction, 6(15%) have grade 2 and 9(22.5%) had grade3 diastolic dysfunction. Progressive increase in LAVI was seen with increasing severity of diastolic dysfunction. Mean LAVI in normal persons was 23.49±4.009 ml/ sqm and in patients with diastolic dysfunction, it was 29.38±4.45, 39.44±8.19, 44.33±5.54 ml/sqm in grade 1, grade2 and grade3 diastolic dysfunctions groups respectively.

KEYWORDS: Diastolic dysfunction, left atrial volume index (LAVI), delayed relaxation, pseudo normalization, restrictive filling.

INTRODUCTION: Although cardiac performance is traditionally focused on Ejection fraction an index of systolic function, diastolic function has been found to play an important role in morbidity and mortality. Clinical manifestations of diastolic dysfunction may vary from relative to asymptomatic state to a patient with overt heart failure. Diastolic heart failure (heart failure with preserved systolic function) constitutes about 20- 40% admissions of heart failure. Isolated diastolic dysfunction is associated with adverse survival, increased incidence of heart failure, stroke, atrial fibrillation.[2]

Diastole consists of 4 phases:

1. Isovolumic relaxation (IVRT).
2. Early rapid diastolic filling.
3. Slow diastolic filling (diastasis).
4. Atrial filling phase.

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Stages of diastolic dysfunction[2]:

Parameter	Normal	Delayed relaxation (Type1)	Pseudo normal (Type 2)	Restrictive filling (Type 3)
E/A	>1	>1	1-2	>2
EDT (m sec)	<220	>220	150-200	<150
IVRT (m sec)	<100	<100	60-100	<60
Pul Vein gS/D	≥ 1	≥ 1	< 1	< 1
Pul AR cm/sec	< 35	< 35	≥ 35	≥ 25

Table 1: Grades of diastolic dysfunction

Diastolic function is influenced by several factors, predominantly myocardial relaxation, ventricular filling pressures, ventricular passive diastolic compliance and heart rate. Left atrium is directly exposed to LV pressures in diastole. Chronic sustained elevation of elevated diastolic filling pressures result in left atrial remodeling resulting in its enlargement.[3]

Left atrium modulates left ventricular filling through 3 components:

1. Phase of reservoir or expansion during systole.
2. Conduit phase in early diastole, mid diastole.
3. Active contractile component in late diastole.

Normally 75-80% of filling occurs in early diastole. Around 15-20% occurs in atrial systole. This active contractile component has an important role with ventricular dysfunction as a booster pump to augment ventricular filling.[4]

Traditionally left atrial size is determined from the parasternal long axis view at end systole. However the size of the LA dimension may be underestimated from the parasternal view because the chamber may enlarge longitudinally. Therefore left atrial size should also be measured in apical views (from the tips the mitral valve to the posterior wall of LA. However the left atrial volume is a better measure of LA size and provides better prognostic value. There are various methods for determination of left atrial volume, the biplane area length method is the currently one recommended by the American society of Echocardiography (ASE). Echocardiographic measurements of LA volume Measurement of left atrial (LA) volume from area-length (L)

METHODS: Usingapical4-chamber (A4C) and apical2-chamber (A2C) views atventricular end systole the endocardial area of left atrium is traced (A1 and A2). Length of LA (L) is measured from back wall to line across hinge points of mitral valve. Shorter L from either A4C or A2C isused inequation.

LA volume is calculated by using the formula [5]:

LAV = 8/3 ∏ (A1 X A2)/ L

=8.5(A1XA2)/L.

The influence of body surface area is corrected by dividing LA volume by body surface area to get LA volume index (LAVI). The normal value for all age groups is 22 ± 6 ml/m^2.

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Grading of left atrial volume index (LAVI):

	Normal range	Mildly dilated	Moderately dilated	Grossly dilated
LAVI (ml/m^2)	22 ± 6	29 - 33	34 - 39	≥ 40

Table 2: Grading of left atrial volume index (LAVI) both in adult men & women[6]

Left atrial volume index (LAVI) as a marker of diastolic Dysfunction: A study by Pritchett et al.[7] showed that LAVI increases progressively with increasing severity of diastolic dysfunction. Age, LV mass index, diastolic function grade all have positive correlation with LAVI whereas female gender and higher EF were inversely correlated. They found that LAVI is highly sensitive and specific for the detection of severe (Grade 3) diastolic dysfunction but not a robust marker of mild to moderate diastolic dysfunction.

AIM: To measure the left atrial volume and diastolic function in 60 subjects and to study the correlation if any between left atrial volume and degree of diastolic dysfunction measured by conventional Doppler echocardiography.

METHODS: A total of 60 consecutive subjects above the age of 30 yrs referred to the echocardiography at the cardiology dept, Government General Hospital, Guntur were studied.

Exclusion Criteria:

1. Patients with organic valvular disease.
2. Patients with Left ventricular systolic dysfunction (LV EF < 50%).
3. Patients with more than mild MR (MR jet area >4 sqcm).
4. Patients with other than sinus rhythm.
5. Inability to obtain adequate Echo window.

All subjects underwent transthoracic echocardiography and Doppler imaging and the measurements were obtained. Body surface area (BSA) was calculated using Dubois nomogram after recording weight and height.

Mitral inflow was assessed with pulse Doppler echocardiography from apical 4 chamber view keeping the sample volume at the tips of mitral leaflets. From the inflow profile mitral E wave and A wave, E deceleration time (EDT), IVRT were calculated. Pulmonary venous Doppler flow was recorded with pulse Doppler with sample volume placed approximately I cm into Right upper lobe pulmonary vein and systolic, diastolic forward flows (S, D) and AR (atrial reversal wave) were measured.

Diastolic filling was categorized as normal (Grade 0) impaired relaxation (Grade 1), pseudo normal pattern (grade 2), restrictive filling (Grade 3) by a combination of transmitral and pulmonary venous flow patterns as recommended by Canadian consensus on diastolic dysfunction. Mitral E/A ratio was used for initial categorization If E/A is less than 1 – grade 1 diastolic dysfunction present. If E/A>1 with E deceleration time > 140 msec diastolic flow can be graded as normal or pseudo normal. Pulmonary venous Doppler S/D ratio was utilized then, and if S/D ratio was >1, indicating normal pattern (Grade 0) and S/D ratio<1 indicating pseudo normal pattern (grade 2). If E deceleration time is <140 msec and S/D ratio <1 diastolic function was graded as restrictive (Grade 3).

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LA volume is measured by biplane area length method from apical 4 chamber and 2 chamber views at end systole and area (A1, A2) was calculated by tracing the endocardial border. Long axis (L) was taken as minimum length from the plane of mitral annular plane to the roof of LA. LA volume is calculated by using formula

LAV = 8/3 ∏ (A1 X A2)/ L = 8.5(A1XA2)/L. A volume was indexed to BSA (LAVI)

Statistical analysis: Data was expressed in mean±SD. Comparison between groups was made using t test. A p value of <0.05 was considered significant. Correlation of LAVI and echo cardiographic variables was made using liner regression model.

RESULTS: Baseline characters of the study population are a follows:

Parameter	Normal (n=20)	Diastolic dysfunction (n=40)	P value
Age in yrs	43.4 ±7.96	56.15 ± 8.2	<0.001
Male/Female	16/4 (4: 1)	27/ 13 (2.07: 1)	
HTN	5 (25%)	33 (82.5%)	<0.01
Diabetes	4 (20%)	20 (50%)	0.01
Smoking	6 (30%)	13 (32.5%)	NS
Height in cm	161.5 ± 6.95	160 ± 7.83	NS
Weight in kg	62 ± 9.45	62.2 ± 8.41	NS
BSA (sq m)	1.63 ± 0.139	1.63 ± 0.13	NS

Table 3: Baseline characters of various groups

When compared to normal controls, patients in the diastolic dysfunction group were older and there is increase in the incidence of hypertension and diabetes.

Echo parameter	Normal (N=20)	Grade 1 (N=25)	Grade2 (N=6)	Grade 3 (N=9)
EF	59.25± 7.38	62.96± 9.14 P - NS	61.66 ± 4.08 P - NS	60.44 ± 8.87 P - NS
E/A	1.54 ± 0.27	0.77 ± 0.17 P <0.0001	1.48 ± 0.47 P - NS	1.86± 0.34 P – 0.01
EDT	162 ± 21.11	201 ± 47.78 P -0.0015	175 ± 20.73 P -NS	111.11 ± 12.69 P <0.0001
IVRT	84.75 ± 16.81	99.4 ± 20.42 P – 0.013	76.67 ± 18.62 P- NS	61.11 ± 6.01 P – 0.0009
Pul venous S/D	1.18 ± 0.25	1.37 ± 0.32 P- 0.0352	0.83 ± 0.42 P – 0.01	0.64 ± 0.17 P – 0.0001
Pul venous AR	32.5 ± 10.07	33.2 ± 5.36 P- NS	40.33 ± 7.86 P – NS(0.09)	39.51 ± 8.28 P - NS(0.07)
LAVI	23.49 ± 4.009	29.38 ± 4.45 P < 0.0001	39.44 ± 8.19 P < 0.0001	44.33 ± 5.54 P < 0.0001

Table 4: Echo parameters in various subgroups

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When echo parameters were compared Left ventricular ejection fraction did not differ significantly between all groups. Among diastolic dysfunction group, 25(62.5%) had Grade 1 diastolic dysfunction, 6 (15%) have grade 2 and 9 (22.5%) had grade3 diastolic dysfunction.

Progressive increase in LAVI was seen with increasing severity of diastolic dysfunction. Mean LAVI in normal persons was 23.49±4.009 ml/ sqm and in patients with diastolic dysfunction, it was 29.38±4.45, 39.44±8.19, 44.33±5.54 ml/sqm in grade 1, grade2 and grade3 diastolic dysfunctions groups respectively.

Correlation of LAVI with various echo Parameters:

variable	R value	P value
EF	-0.07	NS
E/A	0.166	NS
EDT	-0.241	0.05 – 0.1
IVRT	-0.31	0.01-0.05
S/D	-0.465	<0.001
Pul AR	0.24	0.05-0.1
Diastolic dysfunction grade	0.831	<0.0001

Table 5: Correlation of LAVI with other echo parameters

When LAVI is correlated with other parameters, it is significantly correlated with grade of diastolic dysfunction, and Pul venous S/Dratio and weak negative correlation with EDT, IVRT and weak positive correlation with pulmonary venous AR wave .

LA size: LA VI (ml/sqm)	Normal (20)	Grade1 (25)	Grade2 (6)	Grade3 (9)
Normal (22-28)	18 (90%)	12 (48%)	1 (16.6%)	0
Mild dilated(29-33)	2 (10%)	8 (32%)	0	0
Moderately dilated(34-39)	0	5 (20%)	1 (16.6%)	4 (44.4%)
Grossly dilated(>40)	0	0	4 (66.7%)	5 (55.6%)

Table 6: LAVI vs Severity of LV dysfunction

When LAVI is compared in various groups in persons with normal diastolic function LA VI is normal in majority of cases, in the grade 1 group roughly half have normal and half have mildly and moderately dilated LA. In grade 2 and grade 3 groups (with increasing severity of diastolic dysfunction, the size of left atrium is increased and majority showed moderate to severe dilatation of Left atrium.

When 29 ml/sq m LAVI is taken as cut off point for differentiation of normal and patients with diastolic dysfunction, the results were as follows:

	Normal	Diastolic dysfunction	Total
No of Pts with LAVI >29 ml/sqm	2	27	31
No of Ptswith LAVI <29ml/sqm	18	13	29
Total	**20**	**40**	**60**

The cut off value of LAVI 29ml/sqm has sensitivity of 67.5%, specificity of 90%, positive predictive value of 87% in identifying patients with diastolic dysfunction.

DISCUSSION: A total of 60 patients were studied for LA volume and diastolic function, of which 20 had normal diastolic function and 40 had diastolic dysfunction. In our study left atrial size as assessed by LAVI (Left atrial Volume index) was correlated with severity of LV dysfunction.

Although LAVI is associated with severity of diastolic dysfunction and when cut off point was taken as 29ml/sqm, 52% showed increased LAVI and in 48%, LAVI is less than 29ml/sqm. where as in grade 2 and grade 3 diastolic dysfunction groups, 88%, 100% had increased LAVI above 29ml/sqm BSA. Matsuda et al demonstrated that LA maximal volume increased with increasing severity of diastolic dysfunction .Our study results are consistent with that study. Duration of diastolic dysfunction is another important factor determining the LA enlargement.

In the present study we find that LAVI is highly sensitive and specific for the detection of moderate to severe diastolic dysfunction and is less useful marker for detection of mild diastolic dysfunction. The present results are consistent with the similar study done by Pritchett et al.

Grade of diastolic dysfunction was significantly correlated with LAVI and pulmonary venous S/D and IVRT were significantly correlated negatively with LAVI.

Comparison of present study with similar study by Pritchett et al.

LAVI	Pritchett et al	Present study
Normal	23 ±6	23.49 ± 4.009
Grade 1	25 ± 8	29.38 ± 4.45
Grade 2	31 ± 8	39.44 ± 8.19
Grade 3	48 ± 12	44.33 ± 5.54

SUMMARY & CONCLUSIONS:

1. Left atrial Volume index(LAVI) and LV diastolic function were measured in a total of 60 patients above 30 yrs of age with normal systolic function (LV EF>50%).
2. 40 had diastolic dysfunction and 20 had normal diastolic function.
3. Among those with diastolic dysfunction 25 had impaired relaxation (Grade 1), 6 had pseudo normal pattern (grade 2) and 9 had restrictive pattern (Grade3).
4. With LAVI 29 ml/sqm BSA as taken as threshold point27 patients (67.5%) in the diastolic dysfunction group had enlarged LA. whereas only 2(10%) in the normal group had enlarged LA.

CONCLUSIONS: LAVI is increased progressively with increasing severity of diastolic dysfunction .It is a sensitive and specific marker for moderate to severe diastolic dysfunction and a less useful marker for detecting mild diastolic dysfunction.

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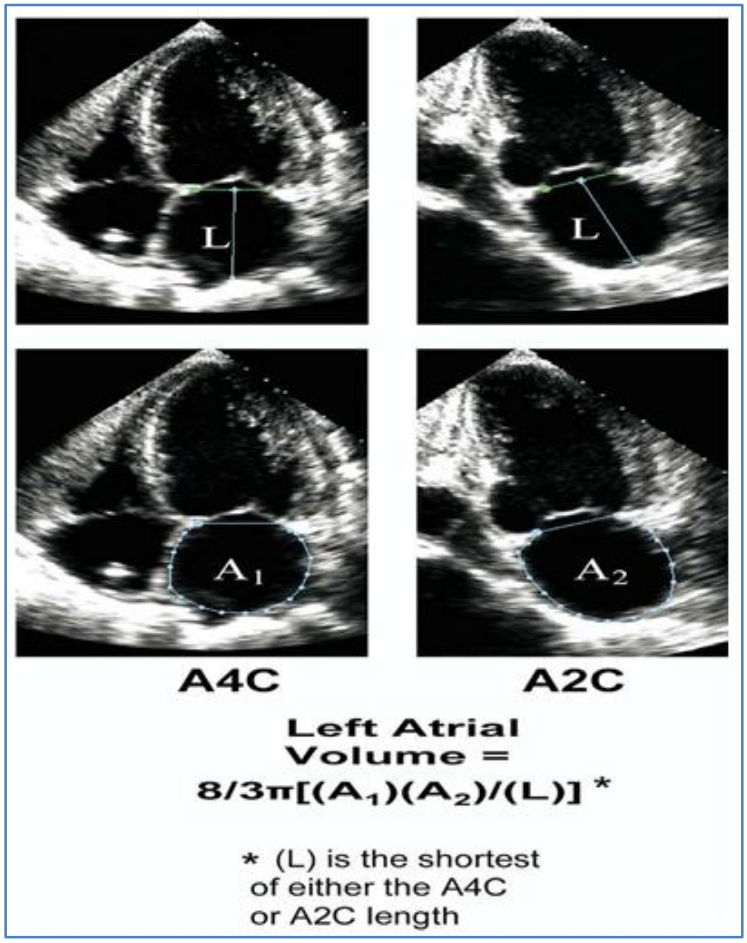

Figure: Calculation of Left atrial volume by biplane area – length method

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