# Left Atrial Appendage Contraction Velocity as a Predictor of Left Ventricular Function

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## Abstract

***Background***- Left atrial appendage contraction velocity (LAAV) is used frequently as a surrogate for global left atrial function, but the validity of this parameter for the prediction of left ventricular systolic and diastolic function has not been evaluated extensively**.** The objective of this study was to assess the relationship between LAA contraction flow velocity and left ventricular systolic and diastolic function parameters.

***Methods***- This study was performed on 142 patients-62 male (43.5%) and 80 female (56.5%) – who were referred for an evaluation of the source of emboli. Exclusion criteria were significant valvular abnormality, prosthetic valve replacement and congenital heart disease.

***Results***- The correlation between LAA contraction velocity and systolic ventricular function was significant (*p* value=0.05). There was an inverse relation between LAA contraction velocity and LV contraction: in 78 patients with LVEF<50%, mean LAAV was about 29cm/s, while in 64 patients with LVEF>50%, mean LAAV was about 50cm/s. Regarding diastolic flow parameters and pulmonic vein flow, patients were classified into four groups as follows: 1) 76 cases with normal patterns, 2) 38 cases with impaired LV relaxation, 3) 16 cases with pseudo-normalization and 4) 12 cases with restrictive patterns. Statistical analysis did not show significant correlation between LAAV and diastolic function (*p*=0.236). Correlation between diastolic function parameters and LAA contraction velocity revealed a significant relation between LAAV and A wave velocity of mitral inflow (*p*=0.02) and no significant relation between LAAV and other diastolic parameters including E wave velocity, DT and IVRT (*p*=0.66, *p*=0.73, p=0.79). ECG showed 98 cases with normal sinus rhythm (NSR), 9 with complete atrioventricular block (CAVB) and 35 with atrial fibrillation (AF). There was a significant reduction in LAAV in AF rhythm compared to NSR.

***Conclusion***- LAA contraction velocity has a close relation with LV systolic function, but not diastolic function. Therefore, LAA contraction velocity should be considered a surrogate for left ventricular systolic function ***(Iranian Heart Journal 2005; 6 (3): 22-28).***

**Keywords:** echocardiography Ë left atrial appendage Ë contraction velocity Ë left ventricular function

Echocardiographic assessment of left atrial appendage (LAA) has become a routine part of transesophageal echocardiography (TEE).[1] Late diastolic LAA outflow velocity, resulting from LAA contraction referred to as "LAA contraction velocity", is clinically applicable as a representative of LAA contractile (systolic) function.[1]

Several recent studies have used the velocity of LAA contraction as possible surrogates for global LA contractile function,[2-5] but an evaluation of this parameter for predicting global ventricular function has not been extensively evaluated. Furthermore, the validity of this approach is questionable and has not been confirmed.[1,2]

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The objective of this study was to assess the relationship between LAA contraction velocity and multiple variables related to left ventricular contraction and relaxation in a relatively large group of participants. Relation between left atrial appendage contraction velocity and spontaneous echo contrast or thrombus in LA/LAA has also been evaluated.

## Methods

142 patients- 62 males (43.5%) and 80 females (56.5%) - aged between 16-76 years with a mean age of 48 years enrolled in this study. NSR was detected in 98 patients, atrial fibrillation in 35 patients and CAVB in the other nine.

The patients were referred to the echocardiography laboratory for an evaluation of the source of emboli and LV function.

TEE and TTE were performed successfully without complications in all of the patients. Exclusion criteria included valvular abnormalities, prosthetic valve replacement and congenital heart disease.

### Echocardiography

TTE and TEE were performed at the same time, with the subject in left lateral decubitus position according to standard practice guidelines. Commercially available ultrasonographic instruments (Expert Vivid 3), equipped with 2.0 to 3.5 MHz transthoracic and 3.5 to 7 MHz multiplane transesophageal transducers were used. Local pharyngeal anesthesia and intravenous sedation (midazolam) were used during TEE, as clinically indicated.

The following echocardiographic variables were prospectively measured during TTE (Table I):

1. LVEDD: left ventricular end-diastolic diameter (M-MODE determination),
2. LVESD: left ventricular end-systolic diameter (M-MODE determination),
3. EF: left ventricular systolic function,
4. E wave amplitude (cm/s): representing early diastolic LV filling,
5. A wave amplitude (cm/s): late diastolic LV filling by pulsed-wave Doppler at the level of the mitral leaflet tips in the 4-chamber view,
6. Deceleration time (DT): left ventricular early diastolic filling deceleration time,
7. Isovolumetric relaxation time (IVRT), and
8. Patterns of diastolic function were also determined.

Other parameters measured during TEE were as follows:

Pulmonic venous flow velocities by pulsed wave Doppler study, with sample volume placed approximately 1-2 cm within the pulmonic veins: 1. PVS - maximal systolic flow velocity (cm/s); 2. PVD-maximal diastolic flow velocity; and 3. PVA-maximal reversal flow velocity during atrial contraction and left atrial appendage contraction velocity with 2-mm sample volume placed in proximity to the LAA orifice. Peak late diastolic emptying velocity (LAA contraction-related) was analyzed in the current study. Tricuspid regurgitation peak velocity and pulmonary artery pressure were also determined.

Left ventricular systolic function was assessed by visual estimation in multiple TEE views and M-mode measurement of LV end-diastolic and end-systolic dimensions during TTE. Regarding peak E wave velocity, peak A wave velocity, DT, IVRT and pulmonic venous flow velocities, we categorized LV diastolic function into four groups as follows:

1. Group 1: normal diastolic function (76 pts),
2. Group 2: impaired LV relaxation (38 pts),
3. Group 3: pseudo-normalization (16 pts), and
4. Group 4: restrictive patterns (12 pts).

There was no significant relation between LAAV and diastolic function pattern ($p$=0.236).

### Statistical analysis

Continuous data are summarized as mean and standard deviation or median and inter-quartile range. Continuous data were

compared with standard T-test or Chi-square, as appropriate. The correlation between LAA contraction velocity and global LV variables (systolic and diastolic) were assessed by calculating Spearman's rank correlation coefficients and comparing the mean sample test because of the non-normality of most of the data. Linear regression equations and the corresponding 95% confidence intervals for the regression lines were calculated and displayed for descriptive purposes.

## Discussion

LA cavity and LAA are derived from different origins.[1,2,15,16] The trabecular LAA is a remnant of the embryonic LA, whereas the smooth LA cavity is derived from the outgrowth of the pulmonary veins.[1,14,15]

Loading conditions may differ between the main LA cavity and the LAA. Furthermore, LAA flow velocities may also be affected by LAA size, morphology and left ventricular function, which are highly variable in the population.[1,2-4,6] The normal length and neck width of the adult left atrial appendage in the horizontal and vertical imaging planes are 28±5mm and 16±5mm, respectively. Left atrial appendage anatomic indices are dependent on the imaging plane, with greater neck width and cross-sectional area when observed at a 135-degree imaging plane as compared with a 45-degree or 90-degree plane, consistent with its shape idealized as a special ungula of a right circular cylinder. Multiple lobes and trabeculations are common.[18] In patients with sinus rhythm, four left atrial appendage flow waves have been described: 1) a large positive wave after the electrocardiographic p-wave, which represents left atrial appendage contraction and emptying; 2) a large negative early systolic wave immediately following the QRS complex representing left atrial appendage filling; 3) alternating positive and negative waves of decreasing velocity throughout the remainder of systole representing passive flow in and out of the appendage; and 4) a low velocity positive emptying wave in early diastole, coinciding with rapid left ventricular filling.[15,16] In addition, a low velocity mid-diastolic negative filling wave, representing appendage filling from the pulmonary veins, may follow the early diastolic atrial appendage emptying wave. Of these flow velocities, the first is the most important for the prediction of left atrial and left ventricular function.

Investigators have subsequently characterized left atrial appendage flow patterns as having four distinct morphologic types: type 1: sinus; type 2: flutter (regularized saw-tooth); type 3: fibrillatory (irregular saw-tooth) with ejection velocity greater than 20cm/sec; and type 4: stagnant/absent flow with peak ejection velocity of 20cm/sec or less.

The normal velocities are as follows: left atrial appendage contraction, 46±18cm/s; left atrial appendage filling, 46±17cm/s; and early diastolic filling, 20±11cm/sec.[16-18]

In patients with atrial fibrillation, a regular atrial contraction wave is absent. However, the left atrial appendage continues to contract, resulting in irregular oscillating positive and negative emptying and filling waves with variable velocities.[3,5,6,13]

Factors other than cardiac rhythm that may affect left atrial appendage velocities have recently been reviewed. They include age, heart rate, left atrial contractility, left atrial pressure, left ventricular systolic and diastolic function, mitral stenosis and mitral regurgitation.[6-9,13] The potential clinical utility of assessing left atrial appendage velocities relates to the association of left atrial appendage velocities with left atrial spontaneous echo contrast and left atrial appendage thrombus formation (Fig. 6). Patients with a left atrial appendage contraction velocity of less than 20cm/sec are more likely to have left atrial appendage thrombus and have a greater risk of ischemic stroke compared with patients with velocities of 20cm/sec or greater.[14,17,19] As with transmitral Doppler data, left atrial appendage

flow velocities are dependent on Doppler sample position and loading conditions.

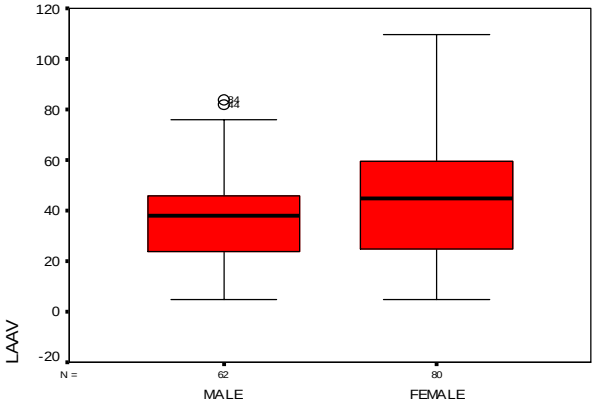
Assessment of systolic and diastolic LV performance is one of the most important elements of diagnostic and therapeutic evaluation in several cardiovascular disorders.[4,6-9] Decreased diastolic LV function is usually accompanied by altered systolic LV function. Nonetheless, in half of the patients with overt heart failure, impaired diastolic LV function is the only abnormality detected during echocardiographic examination.

One of the other implications of LAAV is the prediction of clot formation in the LA and LAA.[1,2,13,16] LAAV below 40cm/s, especially less than 25cm/s, predisposes to severe stasis and thrombus formation in LA and LAA, and the most important complications of this process are stroke and other embolic events.

Advanced age, hypertension, sex, LA function, LV function, atrial rhythm, LA size, hypercoagulopathy and many other factors determine LAAV and chance of clot formation.

## Results

In this research, a comparison between LAAV and sex revealed that mean LAAV in female patients was about 45.5 cm/s and 37.3cm/s in males ($p$=0.028, Fig. 1). ECG showed 98 cases with NSR, 35 patients with atrial fibrillation and 9 cases with complete atrioventricular block. Mean LAAV in the NSR patients was 44.4cm/s, in the AF group 31cm/s and in the CAVB group 40 cm/s ($p$=0.008). There was a significant relation between ESD and LAA velocity ($p$=0.03). With progressive LV dilatation, mean LAAV decreased, but no significant correlation was obtained between EDD and LAAV ($p$=0.185). A comparison between LAAV and ejection fraction revealed a significant correlation (Fig. 2): in 78 patients with LVEF more than 50%, mean LAAV was 50cm/s and in 64 patients with LVEF less than 50%, mean LAAV was 29cm/s ($p$=0.05). A comparison between LAAV and diastolic function parameters revealed the following relations: LAAV and peak A velocity ($p$=0.02); LAAV and peak E velocity ($p$=0.66); LAAV and deceleration time ($p$=0.73); and LAAV and IVRT ($p$=0.79). A comparison between diastolic function pattern and LAAV did not show a significant correlation ($p$=0.236, Fig. 3).




V3 **Fig. 1.** Relation of LAAV with gender.

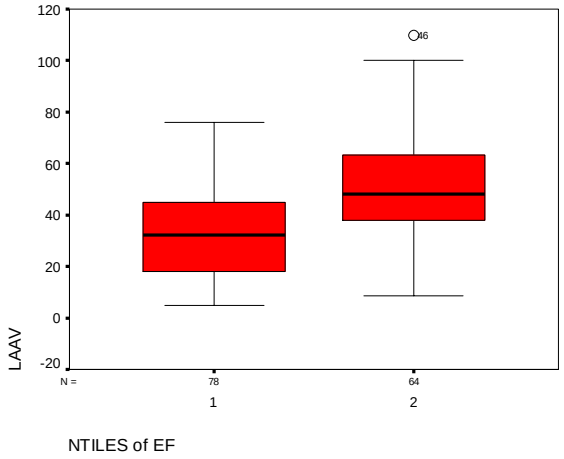



**Fig. 2.** EF and LAAV relation

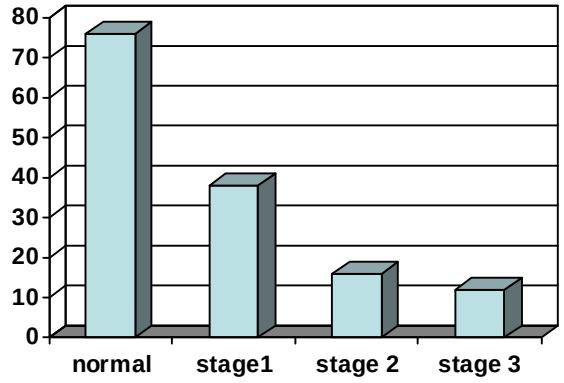



**Fig. 3.** Diastolic function patterns.

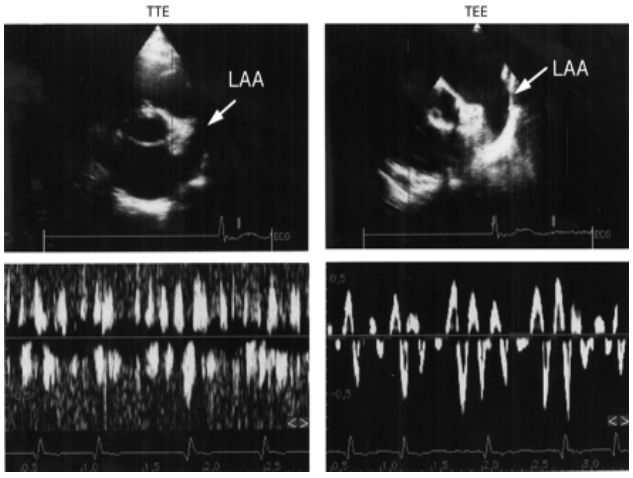



**Fig. 4.** LAA in TTE and TEE with corresponding velocities.

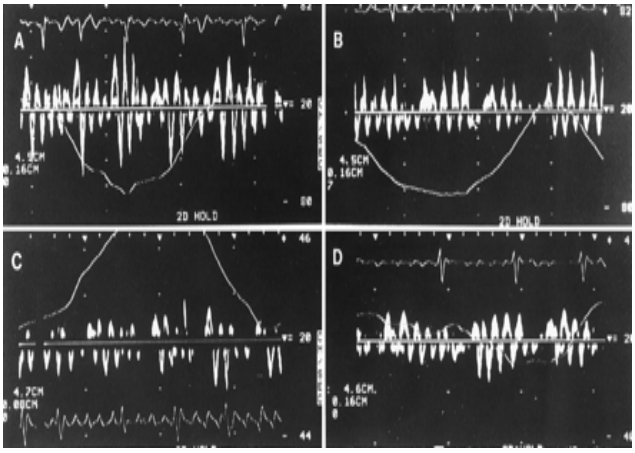



**Fig. 5.** A, B refer to normal LAAV in normal LV function; C,D refer to low LAAV in LV systolic dysfunction.

As mentioned in other articles, LAAV has a close relation with smokey pattern and clot formation in LA and LAA ($p$=0.000). 16 patients, 10% of the total population, had LA/LAA clot. Mean LAAV in these patients was 16cm/s, but in patients without clot it was 47cm/s.

Twenty-five patients also had smokey pattern in LA or LAA. In this group, mean LAAV was about 22cm/s ($p$=0.000).

There was a significant negative relation between left atrial diameter and LAAV ($p$=0.05).

A comparison between pulmonic vein flow velocities and LAAV revealed a close relation between LAAV and diastolic flow velocity ($p$=0.009), but no significant correlation with systolic flow velocity and atrial reversal flow velocity ($p$=0.185, and $p$=0.138, respectively).

There is no significant relation between LAAV with TR severity or pulmonary artery pressure level ($p$=0.56).

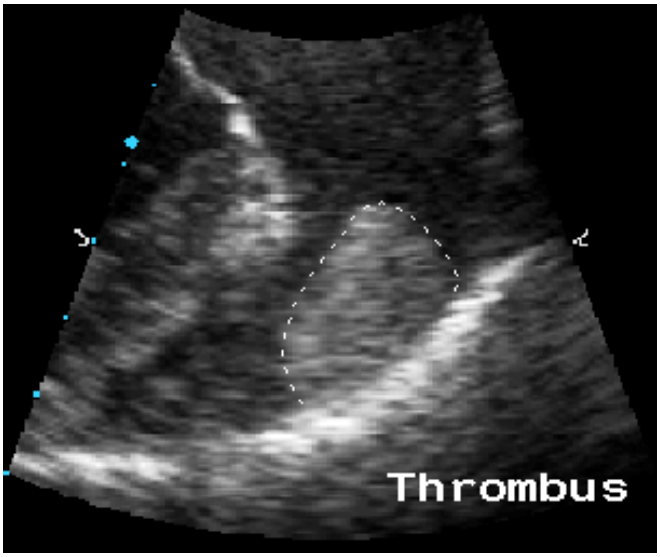



**Fig. 6**. LAA thrombus

**Study strengths and limitations**

This study assessed prospectively the relation between LAA flow and global LV variables. The study participants had been referred for an evaluation of the source of emboli. Multiple systolic and diastolic LV variables were measured during echocardiographic examination (TTE and TEE), allowing to examine several possible associations between LAA and LV function.

## Conclusion

In summary, this study shows that while LAA contraction flow velocity correlates poorly with multiple echocardiographic variables associated with LV diastolic function, it has strong correlation with LV systolic function, left atrial diameter, pulmonic vein diastolic flow velocity, cardiac rhythm, smokey pattern and clot formation in the left atrial appendage. These findings suggest that LAA flow velocity should be used as a surrogate for LV systolic function in clinical practice.

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