Original Article

Comparison of transesophageal echocardiographic assessment of right and left atrial appendage functions

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Objectives: To define right atrial appendage functional parameters and comparing them with those of left atrial appendage.

Methods: A consecutive series of 154 patients (76 males and 78 females) with mean age of 42 years were referred for transesophageal echocardiography. Ejection and filling velocities of right and left atrial appendages were measured at 120 and 70 degrees respectively. The left and right ventricles size and function, right atrial size, tricuspid regurgitation severity, and pulmonary artery systolic pressure were prospectively measured and calculated during transthoracic echocardiography.

Results: Mean right and left atrial appendages velocities were 42 ± 18 cm/s and 50 ± 26 cm/s respectively ($PV<0.001$). Statistically significant positive association ($PV<0.001$) was found between right atrial appendage velocity and right ventricle ejection fraction and statistically negative relationship was observed between right atrial appendage velocity and smoke pattern ($PV<0.001$). Also, the results suggested marginally significant associations between right atrial appendage velocity and right atrium size ($PV = 0.05$) and pulmonary artery systolic pressure ($PV = 0.07$).

It was also found that right atrial appendage measures were relatively independent on right ventricle size and tricuspid regurgitation severity.

Conclusion: Our study showed right atrial appendage measures were relatively dependent on right ventricle function, right atrium size and pulmonary artery systolic pressure and relatively independent on right ventricle size and tricuspid regurgitation severity. In patients with right atrium smoky pattern right atrial appendage velocity was significantly reduced.

Key Words: Transesophageal echocardiography, right atrial appendage, left atrial appendage.

INTRODUCTION

Left atrial appendage (LAA) anatomy and function have been well characterized both in health and disease[1, 2], whereas relatively little attention has been focused on the right atrial appendage (RAA). Transesophageal echocardiography (TEE) is a moderately noninvasive technique that allows superior imaging of both the LAA and RAA[3, 4]. Late diastolic RAA flow velocity, resulting from RAA contraction, referred to as RAA contraction velocity, is clinically representative of RAA contractile (systolic) function. It is not clear that the RAA contraction velocity could be possible surrogates of global right atrium (RA), right ventricle (RV), and left ventricle (LV) contractile function, and pulmonary artery systolic pressure.

The objective of our study was to assess the relationship between RAA contraction velocity and multiple variables related to global RA and RV size and function, pulmonary artery systolic pressure, and LV function in a relatively large group of patients.

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Patients and methods

Study population

The study population consisted of 154 consecutive adult patients (76 males and 78 females) aged from 25-80 years (42± 15 years). TEE was done using a multiplane probe by one attending staff. All patients were in sinus rhythm, excluding those with atrial fibrillation and any kind of cardiac rhythms other than sinus rhythm.

The clinical indications for TEE included evaluation of left ventricular function as a part of serial examination before coronary angiography (n=40), suggesting infectious endocarditis (n=12), cardiac source of embolism (n=23), valvular heart disease (n=53), sizing of atrial septal defect (n=20), and miscellaneous (n=6). All patients underwent successful TEE without any complications.

Echocardiography

Transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) were performed on the same day (1-2 hour apart). Patients were imaged in the left lateral decubitus position using a commercially available system (GE Medical Systems, Vivid 3, Norway) equipped with a 3.5 MHz transthoracic probe and 3.5-5.0 MHz multiplane TEE probe. Patients were studied in the fasting state, using 10% benzocaine spray for posterior pharyngeal anesthesia and mild sedation with midazolam hydrochloride, as needed. Informed consent for TEE was obtained from all participants.

The following echocardiographic variables were prospectively measured and calculated during TTE.

1 Left ventricular end diastolic diameter (LVEDD)
2 Left ventricular end systolic diameter (LVESD)
3 Left ventricular ejection fraction (LVEF)
4 RA and RV size in apical 4-chamber view
5 RV function (by visual assessment, tricuspid annular plane systolic excursion (TAPSE), and tissue Doppler imaging (TDI)
6 Tricuspid regurgitation (TR) severity by color flow Doppler
7 Pulmonary artery systolic pressure (by TR jet)

LAA images were obtained at 70-90 degrees (Fig. 1) and RAA images were acquired at 110-135 degrees (Fig. 2) to facilitate anatomic observations and to attain pulsed Doppler flow velocity profiles within each appendage. LAA and RAA measurements were taken at the onset of the P wave. Individual patient data were

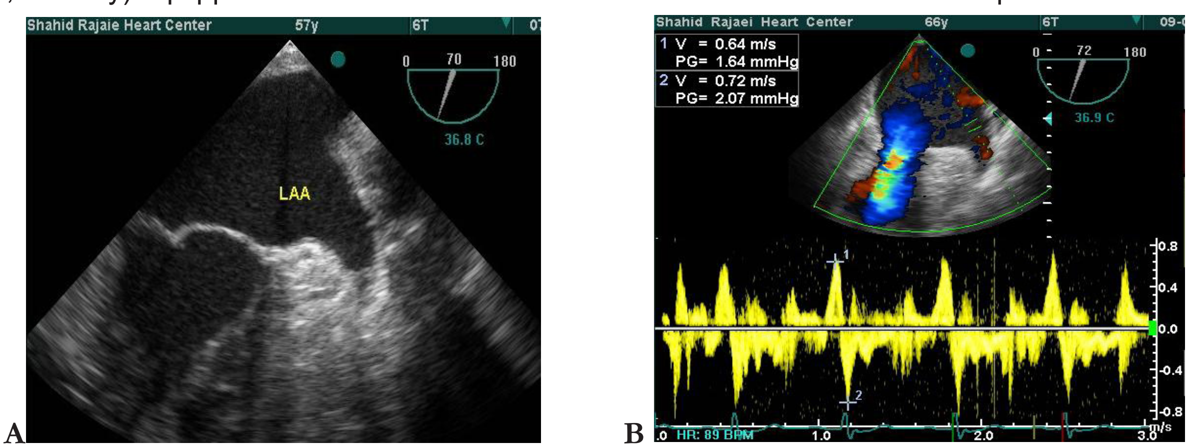
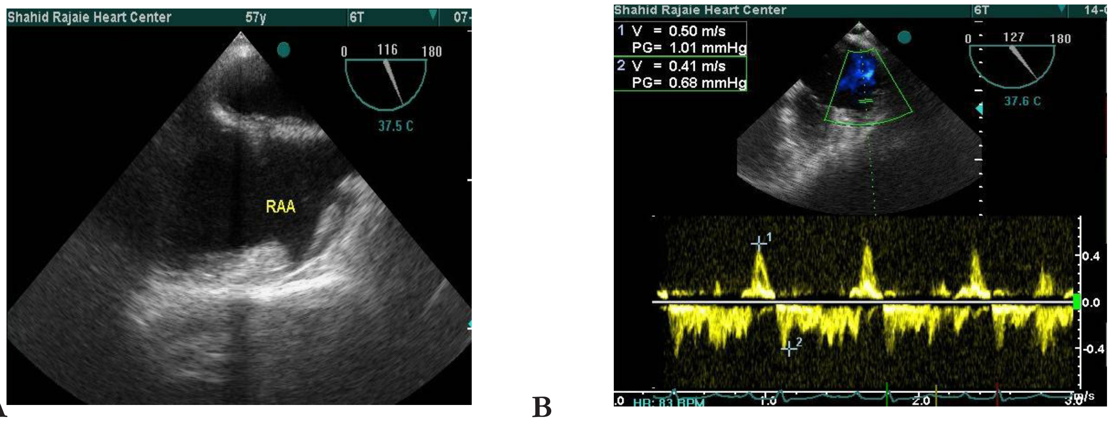


Figure 1, Transesophageal echocardiography of left atrial appendage (*LAA*) at 70 degrees (**A**)**,** Pulsed Doppler LAA flow profile demonstrating LAA velocities (**B**).



A B

Figure 2. Transesophageal echocardiography of right atrial appendage (*RAA*) at 120 degrees (**A**)**,** Pulsed Doppler RAA flow profile demonstrating RAA velocities (**B**).

derived from an average of 3 beats.

Statistical analysis

All data are expressed as mean ± SD. Crude associations between RAA and other variables were determined by independent sample t-test and Mann-Whitney U test for categorical data and bivariate linear regression models for interval data. P value < 0.05 was considered statistically significant. Multivariate analysis was performed, using a multiple linear regression model to determine adjusted associations. SPSS 15 (SPSS Corporation, Chicago, Illinois, USA) was used for statistical analysis.

Results

TEE was done without any complication with visualization of the LAA and RAA in all patients. One- hundred and fifty four Patients, 76 (49%) males, 78 (51%) females with mean age of 42±15 years (Range: 25 - 80 years) participated in this study. LVEF ranged from 20- 70% (53± 7%). In 11 patients (7.3%) LVEF was below 40%. Mean RAA and LAA velocities

Table 1. Associations between RAA velocity and the other echocardiographic determinants

	Mean (SD)	P value
Sex		0.18
Male (n = 76)	44.36 (19.93)	
Female (n = 78)	40.55 (14.76)	
RA size		**0.05**
Normal (n = 102)	43.42 (15.89)	
Large (n = 52)	38.04 (15.00)	
RV size		0.16
Normal (n = 109)	42.55 (16.00)	
Large (n = 45)	38.44 (15.71)	
LVEF		0.50
< 40% (n = 11)	38.73 (17.34)	
> 40% (n = 143)	42.21 (17.50)	
TR		0.63
Mild and mild to moderate (n = 77)	41.92 (15.99)	
Moderate and severe (n = 52)	40.44 (18.67)	
RVEF		**<0.001**
Normal (n = 105)	43.89 (16.12)	
Decreased (n = 49)	32.40 (11.68)	
PASP		0.07
≤ 30 mmHg	44.03 (16.37)	
> 30 mmHg	38.94 (15.43)	
RA Smoky pattern		**<0.001**
Smoke (n = 19)	29.37 (13.91)	
No smoke (n = 135)	42.95 (15.39)	

Table 2. Multivariate analysis for determining the adjusted association between RAA velocity and other variables *

	Coefficient (SE)	P value
LAA	0.33 (0.07)	<0.001
RA size	2.55 (5.14)	0.62
RVEF	-1.39 (4.88)	0.78
RA Smoky pattern	.874 (5.65)	0.88
PASP	-3.01 (4.46)	0.50

* model $r^2 = 0.33$

were 42 ± 18 cm/s and 50 ± 26 cm/s respectively(PV<0.001). This is very similar to those of the other flow velocities in low pressure right side of the heart and seems to be of no clinical significance. LV, RV and RA enlargement was observed in 52 (37.4%), 45 (32.6%), and 52 (38.04%) of the patients respectively. Right ventricle ejection fraction (RVEF) was reduced in 30 patients (22.1%). TR was mild, moderate and severe in 55.4%, 26.2% and 14.6 % respectively. Pulmonary artery systolic pressure (PASP) was normal in 38 % of patients. Mean pulmonary artery pressure was 38 ± 16 mmHg.

Association between RAA velocity and other determinants was investigated by comparing the mean in different categories of other variables models. Detailed data are shown in table 1. Statistically significant positive association was shown between RAA velocity and RVEF (PV<0.001) and statistically negative relation was found between RAA velocity and smoky pattern (PV<0.001). Also, the results suggested marginally significant associations between RAA velocity and RA size (PV = 0.05) and PAP (PV = 0.07).

Using bivariate linear regression models for interval data revealed a weak relationship between RAA and LAA velocities, as independent variable ($r^2 = 0.21$; ß = 0.27, PV<0.001, Fig.3). Using similar models, and considering the age, there were no significant associations between LVEF, PAP, and TR severity as interval data and RAA velocity (all $r^2 < .01$, all PV for coefficients >0.2)

Variables showing a significant or marginally significant relationship with RAA in bivariate analysis, were selected for multivariate analysis. The results are presented in table 2. Only LAA had a significant adjusted association with RAA (ß = 0.07, PV <0.001). Having adjusted and excluding the effect of other variables, only the relationship of LAA and RAA remained statistically significant. However, the magnitude of this association was markedly decreased.

Discussion

The main RA cavity and RAA are derived from different sources during embryogenesis.

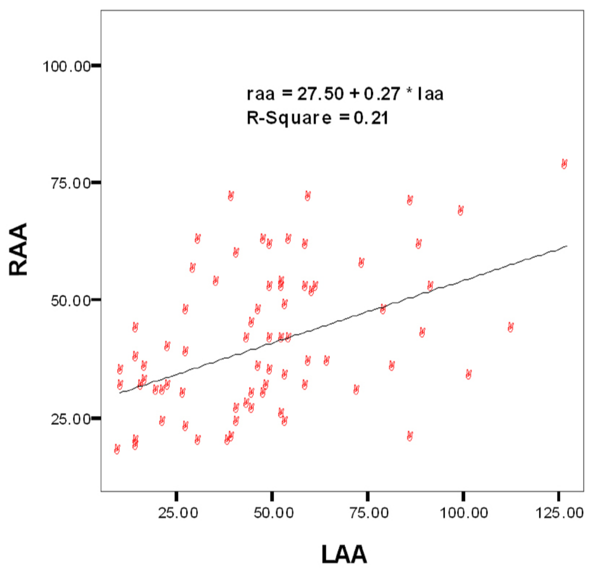


Figure 3. Scatter plot of the relationship between RAA and LAA velocities

The trabecular RAA is a remnant of the embryonic RA, whereas the smooth RA cavity is derived from outgrowth of the caval veins.

Loading conditions may differ between the main RA cavity and the RAA. Furthermore RAA flow velocities may also be affected by RAA size and morphology, LV and RV function, which are highly variable in the population. In patients with sinus rhythm two flow waves have been described; 1) a large positive wave after the electrocardiographic p-wave, which represents RAA contraction and emptying, 2) a large negative early systolic wave immediately following the QRS complex representing RAA filling. The first of these flow velocities is most important for prediction of RA and RV function, such as LAA for prediction of left atrium (LA) and LV function.

The mean range of normal velocities has not been presented in most references. In this consecutive series of patients undergoing TEE, we found RAA measures to be lower than those of LAA. It is the same as those previously reported by Subramaniam et.al [5] who found that RAA ejection velocity was lower than LAA ejection velocity (60.0 ±24.2 versus 40 ±16.4 in sinus rhythm and 26.6 ± 17.6 versus 20 ± 13.6 in atrial fibrillation (PV<0.001). It is most likely to be secondary to smaller LAA neck [5] and also lower right-sided pressures compared with those of left-sided.

In our study, patients with RA smoke pattern had significantly reduced RAA velocity (29.37 ±13.91 versus 42.95 ±15.39, PV<0.001).

We also found that RAA measures were relatively dependent on RV function, RA size and PASP and relatively independent on RV size and TR severity. Significant results in bivariate analysis could be due to the confounding effects of other determinants.

Since our data were derived from a consecutive series of patients referred for clinical TEE, they were not sufficient to define normal RAA ejection velocity. This can only be derived from studies on healthy participants. However, the mean LAA ejection velocity in our sinus rhythm series is similar to that reported for control subjects in other studies [3]. Our RAA data are then, by inference, likely to be similar to a healthy series.

The potential clinical utility of assessing RAA velocities relates to its association with RA spontaneous echo contrast and RAA thrombus formation.

Conclusion

RAA functional parameters were relatively dependent on RV function, RA size and pulmonary artery systolic pressure and relatively independent on RV size and TR severity. In patients with RA smoky pattern RAA velocity was significantly reduced.

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