

A STUDY OF LEFT ATRIAL APPENDAGE FLOW BY DOPPLER TRANSESOPHAGEAL ECHOCARDIOGRAPHY IN PATIENTS WITH ATRIAL SEPTAL DEFECT

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Abstract

Background:

Transesophageal echocardiography TEE is performed in subjects with atrial septal defect (ASD) to define the characteristics of left atrial appendage (LAA) blood flow pattern.

Normally, LAA flow velocity pattern is primarily determined by the left heart performance. We hypothesized that the impact of left – side heart dynamics on LAA flow velocity pattern is diminished in patients with ASD because of the presence of a left –to-right shunt into the low-resistance right side of the heart.

Methods:

Transesophageal echocardiography was performed in 29 adults with a large uncomplicated secundum ASD. Maximum defect diameter varied from 1.40 - to -3.9 cm, mean (2.37 ±0.79) cm. All patients were in normal sinus rhythm.

Results:

In 29 subjects the LAA flow velocity pattern lacked distinct early diastolic LAA outflow wave. Instead, we notice that the early diastolic LAA outflow and LAA contraction waves in late diastolic contraction tend to merge followed by a slightly higher emptying velocity (early systolic velocity).

Conclusion:

The pattern of flow velocity of left atrial appendage by spectral pulsed Doppler echocardiography affected by ASD hemodynamics.

Key words: Transesophageal echocardiography (TEE), left atrial appendage flow, Spectral Doppler, atrial septal defect (ASD).

Introduction

The left atrial appendage (LAA): is a blind ended complex structure is embryologically distinct from the body of the left atrium and is sometimes regarded as just a minor extension of the atrium. ⁽¹⁾

Transesophageal echocardiography (TEE) allows a detailed evaluation the structure and function of the appendage by two-dimensional imaging and pulsed Doppler interrogation of appendage flow. Specific flow patterns, reflecting appendage function, have been characterized for normal sinus rhythm and various abnormal cardiac rhythms⁽²⁾. Echocardiographic assessment of LAA function was initially described by Suetsugu et al. ⁽³⁾ and

by Pollick and Taylor ⁽⁴⁾ and has become an integral part of the routine TEE examination.

Transesophageal echocardiography (TEE) is an excellent imaging tool in the diagnosis and evaluation of ASD⁽⁵⁾.

Atrial septal defect (ASD) is one of the most prevalent form congenital heart disease.

ASDs are classified according to their location in the atrial septum. Ostium secundum defects are in the region of the fossa ovalis, ostium primum in the low atrial septum, and sinus venosus in the upper septum near the junction of the vena cava and the right atrium⁽⁶⁾. Because the side of the heart has a higher compliance and a lower resistance than the left side after birth, ASD most commonly leads to a left-to-right shunt at the level of the atria. The

shunting of the left atrial blood leads to volume overload of the right side of the heart and a subsequent right atrial and right ventricular dilatation.⁽⁷⁾

Echocardiographic data on LAA flow velocity pattern in patients with ASD are scarce. We hypothesized that altered left atrial hemodynamics imposed by the left-to-right shunt in large uncomplicated ASD lead to changes in LAA flow. Such changes, in turn, could help elucidate the hemodynamics of ASD. We aimed primarily to evaluate the deviation from normal in left atrial appendage flow pattern using Spectral Doppler by transesophageal echocardiography in patients with ASD.

Materials And Methods

Patients:

This study group comprised 29 patients with large secundum ASD who underwent transthoracic echocardiography and TEE examination at Ibn AL- bitar Hospital for cardiac surgery, between December and July of 2008. patients included 26 females and 3 males, aged from (16-56) years. (Mean 35.12 ± 11.94).

All patients with left-to-right shunt, who had TEE for pre-operative diagnosis. There were no clinical or echocardiographic signs of significant valvular or myocardial abnormalities, increased pulmonary resistance, or right-to-left shunting. All patients with sinus rhythm.

For obvious ethical and practical reasons, we could not perform TEE on healthy volunteers or patients with normal heart. We made comparison with historical controls.

Left atrial appendage flow categorized into one of the three patterns: biphasic, triphasic and quadraphasic. Quadraphasic signals have been described in patients with sinus rhythm, Fig.(1)⁽²⁾. It was consist of LAA contraction (a-wave), LAA filling, systolic reflection wave (positive and negative), and early diastolic LAA outflow (e-wave).

The normal values for LAA flow were depicted in Table (1).

Table (1)
Left Atrial Appendage Flow Velocities in Patients Without Cardiac Abnormalities.

<i>Study</i>	<i>Study Group</i>	<i>Contraction Velocities, cm/s</i>	<i>Filling Velocities cm/s</i>	<i>Early Forward</i>
Kortz et al. ⁽⁸⁾	46 healthy volunteers; age, 22-41 yr	64±19*	46±12*	38±11*
Tabata et al. ⁽⁹⁾	50 patients with structurally normal heart (clinically indicated TEE)	60±14*	52±13*	20±11*

* *Peak velocities (cm/sec)*

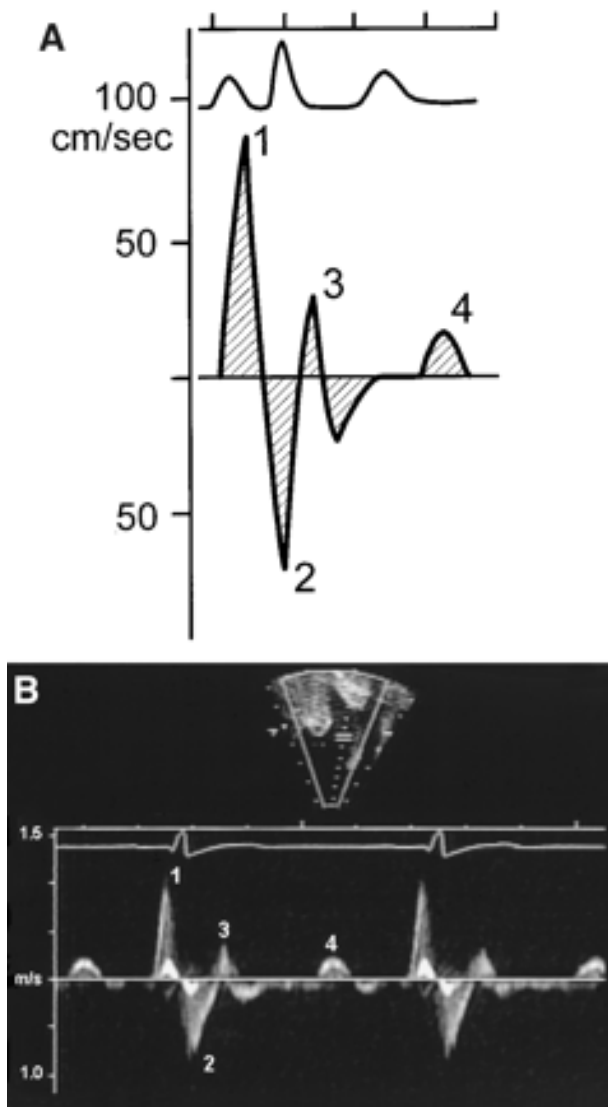


Fig. (1) A, Diagram of LAA flow in sinus rhythm. 1, LAA contraction; 2, LAA filling; 3, systolic reflection waves (positive and negative); 4, early diastolic LAA outflow. B, Pulsed-Doppler tracing of LAA flow in sinus rhythm (flow signals 1 to 4 as in A). From Agmon et al⁽²⁾

Patients Preparation:

Before the examination, patients were studied in fasted state. Sedation with (5-10) mg I.V diazepam was used in approximately 10% of the patients. The pharynx was anesthetized with topical lidocaine spray, and the probe was introduced into the esophagus with the patient lying on the left side, lateral decubitus position with gentle neck flexion⁽¹⁰⁾.

Echocardiography:

All patients were studied using Philips medical ultrasonograph. (Philips Envisor, ultrasound system). Two-dimensional (2D) and Doppler transthoracic (TTE) were performed before the TEE study with a 2-5 MHZ transducer.

TEE was performed using a 5-MHZ omniplane phased-array transducer.

The LAA has been imaged primarily in two basic biplane TEE views:

- The horizontal short – axis view at the base of the heart⁽¹¹⁾ and,
- The two-chamber longitudinal view of the left atrial (LA) and ventricle (LV)⁽¹²⁾.

Multiplane allows greater versatility in obtaining these views and enables visualization of the appendage in continuum intermediate planes⁽⁴⁾.

Measurements obtained from Doppler echocardiographic tracing included the peak velocity (V max), the mean velocity (V mean), and the velocity-time integral (VTI).

Statistical Analysis:

For statistical analysis of the measured data, correlation test (pearson) was used. Averaged data are presented in the form of mean \pm standard deviation (SD) by using statistical software SPSS-version 12, and Excel version 2003.

An estimate was considered to be statistically significant if p-value was < 0.05 .

Results

The maximal defect diameter ranged from (1.40) to (3.9) cm, mean (2.37 ± 0.79) cm.

The direction of the shunt was from the left atrium to the right atrium in all patients. All patients were in normal sinus rhythm.

Left atrial appendage flow velocity pattern:

Table (2) shows left atrial appendage flow velocity for patients with ASD.

The pattern consist of Fig.(2):

- LAA contraction velocity (a-wave) toward the TEE transducer, shortly following the onset of the ECG P-wave. Vmax was (55.28 ± 22.3) .
- LAA filling Velocity:

Negative (a way from the TEE transducer) Doppler in flow signal.

- Systolic reflection waves (positive and negative):

Twenty four patients had negative systolic reflection waves signals. Vmax was (26.89 ± 9.34) cm/sec, some of them had both positive

and negative. Twenty patients had only positive systolic reflection waves. V max was (30.95 ± 12.76) cm/sec.

Early diastolic LAA out flow disappear in all patients. Superposition of (a- wave) on (e-wave) diastolic forward flow wave.

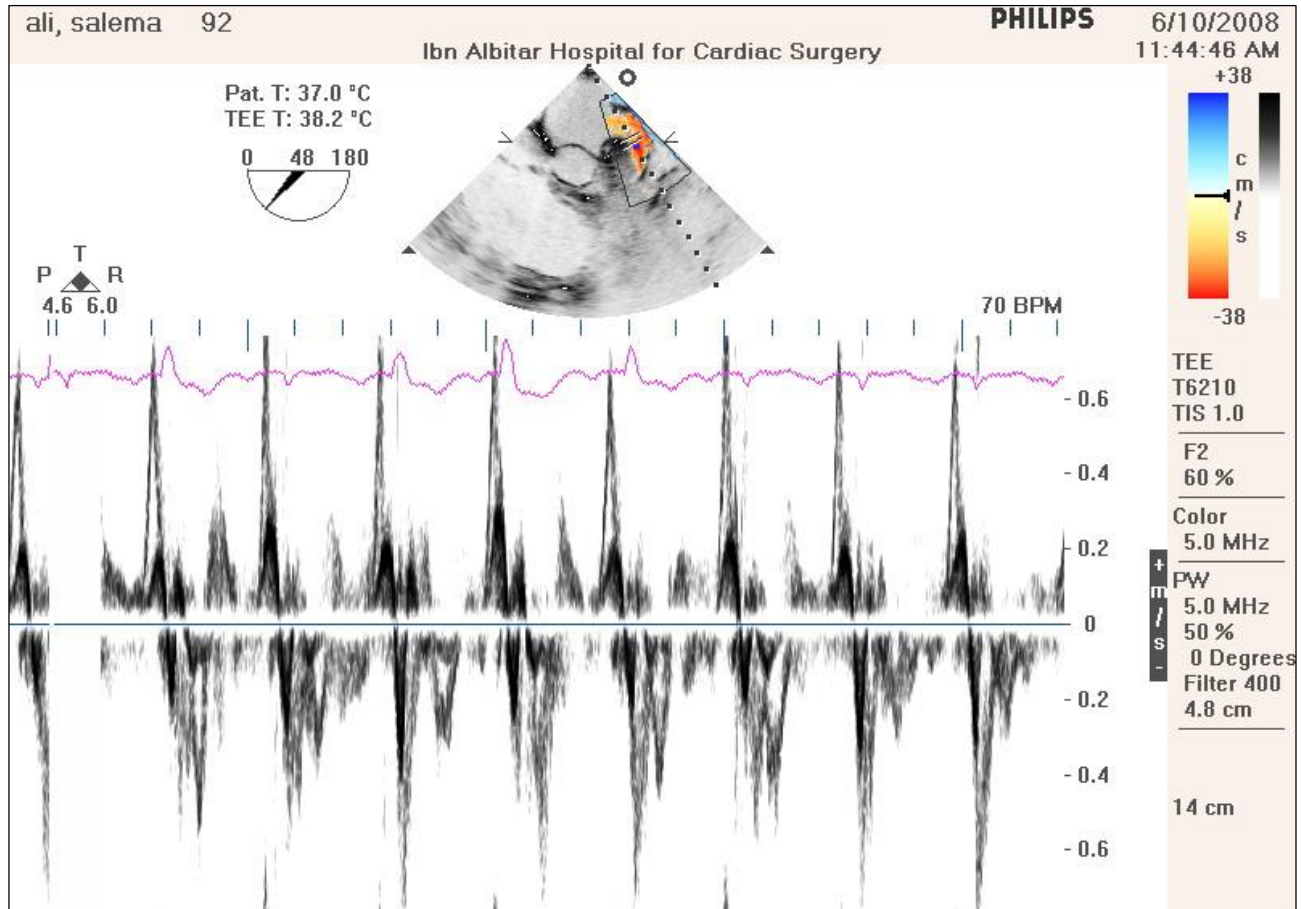


Fig. (2) : Pulsed Doppler recoding of left atrial appendage flow in subject with ASD and in sinus rhythm.

Table (2)
Left atrial appendage flow velocities in (29) patient with ASD.

		Left atrial appendage velocities in (29) Patients with ASD		
		VTI cm	V (max) cm/sec	V mean cm/sec
LAA contraction velocity (cm/sec)	Rang	(1.94 – 8.72)	25.7- 96.3	15.70 – 50.0
	Mean ± SD	4.5232 ± 1.855	55.28 ± 22.30	30.0132± 11.2459
LAA filling Velocity Cm/sec	Range	(1.18 – 8.67)	24.7 – 68.9	1.51 – 38.3
	Mean ± SD	3.5218 ± 1.7517	41.3679± 13.4734	21.2761 ± 8.8473
Systolic reflection cm/sec positive (cm/sec) No:20	Range	0.54 – 5.91	11.0 -61.40	6.61 – 30.0
	Mean ± SD	1.9058±.12476	30.9515± 12.7551	16.9145 ± 5.8480
Negative cm/sec No:24	Range	0.82 – 4.57	12.9 – 44.9	6.96 – 21.6
	Means ± SD	2.3377 ± 1.3647	26.8958 ± 9.336	15.2263 ± 4.2156
Early diastolic LAA velocity cm/sec	Range	–	–	–
	Mean ± SD	–	–	–

VTI: Velocity time integral (cm).

V (max): maximum velocity (cm/sec).

V (mean): mean velocity (cm/sec).

Table (3)
Left atrial appendage flow velocities in patients without cardiac abnormalities (historical controls) and patients with ASD.

		Patients with ASD	Historical controls	
		V max	V max	
			Kortz etal (8)	Tabata etal (9)
LAA Contraction velocity cm/sec	Mean ± SD	55.28±22.3	64±19	60±14
LA filling velocity (cm/sec)	Mean ± SD	41.3679±13.5	46±12	52±13

Vmax: maximum velocity.

The Relation Between LAA Contraction Velocity (Late Diastolic Velocity) A-Wave And Other Velocities Of LAA Flow Pattern:

The relation between LAA contraction velocity and other velocities of LAA flow pattern are show in Table (4).

In a univariate analysis, maximum LAA filling wave and negative early systolic reflection wave were strongly correlated with LAA contraction velocity.

Table (4)
The relation between LAA contraction velocity and other components of LAA flow in patients with ASD.

Parameters	Correlation (r – value)	
	LAA contraction (max) cm/sec	p – value
Maximum LAA filling wave (cm / sec)	0.514	** < 0.001
Maximum positive systolic reflection wave (cm/sec)	0.906	Not significant
Maximum Negative systolic reflection wave (cm/ sec)	0.470	* < 0.05

Discussion

Our study demonstrated that the flow of LAA using TEE in patients with ASD. As a result, a peculiar pattern of LAA flow. In healthy persons with sinus rhythm, Doppler flow signals of LAA consist of four waves. Fig.(1).

The initial antegrade component referred to LAA contraction (a-wave): resulting in a late diastolic, positive (i.e., toward the TEE transducer) Doppler outflow signal, shortly following the onset of ECG P-wave. This signal coincides with two dimensional and color flow imaging of LAA contraction and outflow⁽⁴⁾ and is related temporally to late diastolic mitral flow (mitral A- wave)⁽¹³⁾.

The second component is LAA filling: an early systolic, negative (i.e., away from the TEE transducer) Doppler inflow signal, immediately following left atrial contraction^(4,8).

The third component of LAA is systolic reflection waves: Following LAA contraction and filling and inflow signals of diminishing amplitude are commonly recorded^(4,8), resulting from passive outward and inward flow waves following the initial high velocity flows of appendage contraction and filling. The velocities of reflection waves correlate with preceding LAA contraction and filling velocities⁽¹⁴⁾.

The final wave is the antegrade component early diastolic LAA flow (e-wave), a low velocity outflow signal following, early diastolic mitral flow (mitral E wave), and pulmonary venous diastolic flow signals^(8,15) Initial, it was proposed that early diastolic LAA flow results from compression of the LAA medial wall by the superior motion of the base of the LV during diastole⁽⁴⁾. However, a more plausible explanation is passive emptying of the

appendage, paralleling LA emptying of appendage, during rapid ventricular filling early diastole.

Atrial septal defect dramatically alters cardiac hemodynamics during both ventricular systole and diastole⁽¹⁶⁾. The primary objective of this study was to determine whether this altered cardiac physiology leads to altered LAA flow velocity pattern on TEE. We emphasize that we measured LAA flow velocities rather than volumetric flows.

The principal result of this study is that instead of showing two distinct antegrade diastolic waves (e-wave and a-wave in late diastole) that is seen in normal individual⁽²⁾, the two diastolic waves tend to merge, followed by a slightly higher emptying velocity.

The left-to-right shunt in ASD occurs as a pulsatile flow associated with a left-to-right gradient. This gradient was shown to be at its maximal during the interval of the latter half ventricular systole and the first portion of diastole, with a second accentuation during atrial contracting⁽¹⁶⁾.

In ASD, however, the persistent pressure gradient between the left atrial and right atria at the end of systole is translated into a pressure gradient between the pulmonary vein and right atria. Blood continues to flow through the pulmonary veins at the end of systole, producing added flow wave that is superimposed by the (a-wave) on the (e-wave) there by merging the two waves together.

With this concept in mind, that early diastolic is affected by hemodynamics of ASD rather than the effect of left ventricular function, Fig (2).

This phenomenon has not been previously studied in great detail. This finding, which is a fairly novel one, would be expected to cast further light on the pathophysiology and nature of interatrial shunt.

In this study the patients with ASD demonstrated an interesting finding. There was a significant correlation between maximum LAA contraction velocity and maximum LAA filling wave ($r = 0.514$, p -value < 0.001).

This results are in agreement with other studies Pollick c.etal⁽⁴⁾ and Kortz RA.etal⁽⁸⁾. The physiologic processes underlying LAA

filling have not been studied in detail as have their counterpart ventricular processes and the relative roles of active (LAA relaxation) versus passive (e.g., elastic recoil) processes resulting in LAA filling are poorly defined hence, the preferred general term "LAA filling" is used.

Also a positive correlation between maximum LAA contraction velocity and maximum negative systolic reflection wave ($r = 0.47$, $p < 0.05$), Table (4).

This result in this study is in agreement with that of Fatkin D., et al.⁽¹⁴⁾ and Zeppellini R., et al.⁽¹⁷⁾.

Kortz R.A etal⁽⁸⁾ previously demonstrated that the LAA blood flow pattern in normal subjects is heart rate dependent, the effect of heart rate on the LAA flow velocity pattern in patients with ASD needs further study.

Limitations

Some limitations of this study deserve consideration. First of all, TEE is not performed in healthy subjects because of obvious ethical reasons and TEE is uncomfortable for some patients. Normal people refused TEE examinations, because they are things that there is no need for such a semi-invasive examination. In spite of we selected cases of ASD with sinus rhythm we cannot get rid of the effect of sinus tachycardia in some patients during examination.

The intracardiac pressures were not measured therefore; the implication of PVF on hemodynamics such as atrial pressure could only be postulated.

Conclusion

The previously unrecognized LAA flow pattern sheds new light on the hemodynamics of ASDs. The LAA flow pattern in ASD can help in understanding the assessment of LAA function.

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الخلاصة

المقدمة: ان جهاز صدى القلب عبر المرئ المتضمن تأثير دوبلر النبضي يمثل افضل طريقة لدراسة جريان الدم في اللاحقة الاذينية.

طريقة البحث : تم استخدام جهاز صدى القلب بالامواج فوق الصوتية عبر المرئ (والمضمن تأثير دوبلر النبضي) لدراسة جريان الدم عبر اللاحقة الاذينية والذي يتأثر بالتغيرات القلبية المختلفة .

هدف الدراسة: دراسة جريان الدم عبر اللاحقة الاذينية باستخدام جهاز صدى القلب عبر المرئ.

النتائج: ان سلوك جريان الدم في اللاحقة الاذينية يشتمل على نمط يختلف عن النمط الطبيعي.

الاستنتاج: ان جريان الدم عبر اللاحقة الاذينية يساعد في فهم هيموداينمك الفتحة بين الاذنين.