Pulmonary Venous Flow in Patients with Secondum ASD Before and After Occlusion By Amplatzer Septal Occluder

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Abstract

Objectives: To clarify the importance of Pulmonary venous flow (PVF) pattern and velocity in patients with hemodynamically significant secondum atrial septal defects(ASD) before and after Amplatzer septal occluder(ASO).

Method: prospective study in consecutive individuals. Sixty four consecutive patients with hemodynamically significant secondum ASD who were referred for ASO were included in the study. ASO procedure was done according to the standard technique. Measurements of PVF of left upper pulmonary vein (LUPV) were done while the patient under general anesthesia just before and immediately after the occlusion. After occlusion, any residual shunt was looked for by Transesophageal echocardiography (TEE) and/or angiography.

Results: In this study, before ASO, 57 (89.06%) patients with secondum ASD had the monophasic pattern and 7(10.93%) patients had the biphasic pattern seen in normal subjects. Also we found that 12 (18.75%) patients got residual shunt after occlusion either a second small ASD, a PFO or shunt through the struts of occluder thought to close later on, two of them with persistent monophasic pattern. The majority of patients with residual shunt failed to drop peak PVF velocity by ≥ 30%.

Conclusion: The presence of monophasic PVF pattern signifies the presence of ASD with significant left-to-right shunt. Also the PVF pattern and velocity before and after ASO is an important guide to a successful occlusion of an ASD.

Keywords: PVF, secondum ASD, ASO

Introduction

Pulmonary venous flow (PVF) pattern was of great interest for many years, with its relation to various cardiac abnormalities, but PVF pattern in patients with ASD was studied lately[1,2].

Hoffman et al described a unique pattern of PVF in 93% of patients with secondum ASD with significant left –to- right shunt. They concentrated on the PVF pattern and velocity in 40 patients with control group[3].

Saric et al described the same pattern in patients with large ASD and return of normal pattern after surgical closure. They looked for PVF pattern and the reverse flow (a-wave) of 22 patients, and mentioned the return of PVF pattern to normal in the 3 patients who had surgical occlusion[4].

Chockalingan et al also described the same pattern. They reported the PVF pattern in 36 patients, using transthoracic echocardiography, and follow-up of 11 patients postoperatively[5].

Using hemodynamic recordings, Levin et al demonstrated that the left-to-right shunt in ASD occurs as pulsatile flow associated with a left atrium (LA) -to- right atrium(RA) gradient. This gradient was shown to be at its maximum during the interval of the latter half of ventricular systole and the first portion of diastole, with accentuation during ventricular contraction. Using quantitative cineangiography, the authors also showed that the major shunt across the defect occurred during those intervals of prolonged pressure gradient. Therefore, normally blood flow towards the LA decelerates or ceases at the end of systole due to the rise in LA pressure and equilibration of pressures between the LA and pulmonary veins. In ASD, however, the persistent pressure gradient between the LA and RA at the end of systole is translated into a pressure gradient between the pulmonary veins and RA. This persistent gradient is expected to cancel the deceleration or cessation of flow that occurs normally towards the end of systole. Instead, blood continues to flow through the pulmonary veins at the end of systole, producing an added flow wave that is superimposed on the original flow wave tracing, thereby merging the two waves together in a single and continuous wave.[6] Normal mean PVF velocity ranges from 0.41±0.10 m/s in patients <40 years to 0.6±0.1m/s in patients > 60 years of age [7].

Normal PVF pattern:

The normal PVF pattern has S-wave due to both atrial relaxation and rotation of mitral valve annulus, if happened simultaneously it will result in one peak, if not it will result in two peaks. The D-wave is due to ventricular relaxation, while the a-wave is due to atrial contraction[8].

PVF in patient with ASD secondum:

It consists of one wave (monophasic) which represents the forward, and no reversal flow (a-wave).

So we aimed to clarify the unique pattern of PVF in patients with hemodynamically significant secondum ASD and its importance in understanding the pathophysiology of ASD, in addition to the importance of PVF velocity before and after ASO in evaluating residual shunt.

Patients & Method

Study group:

Sixty four consecutive patients with hemodynamically significant secondum ASD who were referred for ASO were included in the study.

The ages of patients ranged between 2-65 years. There were 41 (64.06%) females and 23(35.93%) males.

ASO procedure was done according to the standard technique.[9]

TEE was done previous to /or during the procedure while the patient under general anesthesia to characterize the lesion morphology and eligibility for ASO. Only patients with pure secondum ASD were included in our study.

Echocardiography:

TEE was done using Voluson 5500,Cretz software. The measurement technique include selecting the appropriate image which is the basal short axis scan of the transverse plane, the left upper pulmonary vein (LUPV) lies posterior to the left atrial appendage and anterior to the descending thoracic aorta. Two-dimensional echocardiographic identification of the vein should be confirmed by color flow Doppler imaging. The spectral display pulsed-Doppler cursor is then positioned proximal (1 to 2 cm) to the entrance of the vein into the left atrium. The line of beam interrogation was placed as parallel to flow as possible.

Measurements of PVF of LUPV were done while the patient under general anesthesia just before and immediately after the occlusion. After occlusion, any residual shunt was looked for by TEE and/or angiography. In addition, maximal velocity, age, and ASD size were recorded. Of note is; we didn't take measurements for the a-wave because it was indistinct in most of the patients, so we concentrated on forward flow only, and we recorded the pattern either monophasic or biphasic.

Statistical analysis:

Data analyzed using Paired-t-test as needed to evaluate significancy, with a value of 0.05 as level of significance.

Results

Table (1) shows the basic characteristics of the patients. The patients' ages ranged from 2-65 years.

Most of the patients had the unique monophasic pattern (figure 1)

All patients had successful closure of the defects; however, 12 patients (18.75%) had residual shunts after ASO deployment, either through a second small ASD, a patent foramen ovale, or through the struts of the occluder, thought to close later on.

PVF velocity declined significantly after ASD closure (table 2, figure 2), this reduction was significant whether the initial PVF pattern was monophasic or biphasic and whether or not a residual shunt was present (table 2).

Before ASD closure, patients with monophasic flow pattern had significantly higher peak PVF velocities than their counterparts with biphasic pattern (0.76±0.18 m/s vs 0.59±0.26 m/s, P=0.032) (table 2).

Table 1: basic characteristics of patients with ASD secondum

Variable	**value**
Number	64
Age (yr.)	2-65
Male no. (%)	41(64)
patients with monophasic PVF no. (%)	57(89.06)
Patients with biphasic PVF no (%)	7(10.93)

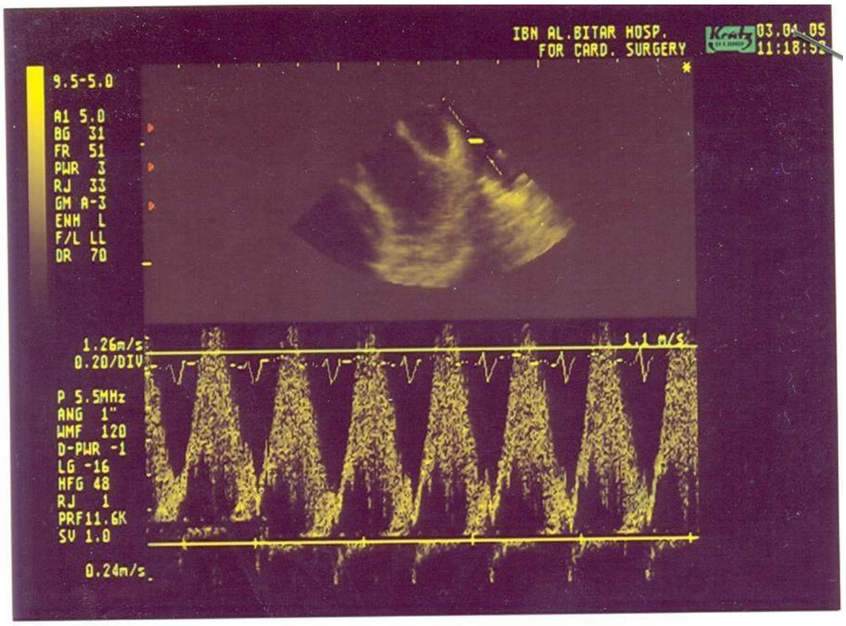

Fig. 1: PVF pattern in patient with hemodynamically significant secondum before ASO.

Table 2: shows the peak pve before and after ASO

Peak PVF velocity (m/s)	Before ASO			After ASO			Difference (%)	P value
	Min	Max	Mean(±SD)	Min	Max	Mean(±SD)		
All patients no 64	0.4	1.3	0.74±0.19	0.2	1	0.48±0.16	34.82	0.0001
Biphasic No 7	0.4	1.1	0.59±0.26	0.2	0.9	0.42±0.23	30.41	0.001
Monophasic No 57	0.4	1.3	0.76±0.18	0.2	1	0.48±0.15	35.37	0.0001
Patients with residual shunts No. 13	0.5	1.05	0.7±0.2	0.3	1	0.57±0.19	24.77	0.0001
Patients with no residual shunts No. 52	0.4	1.3	0.73±0.2	0.2	0.9	0.45±0.15	37.15	0.001

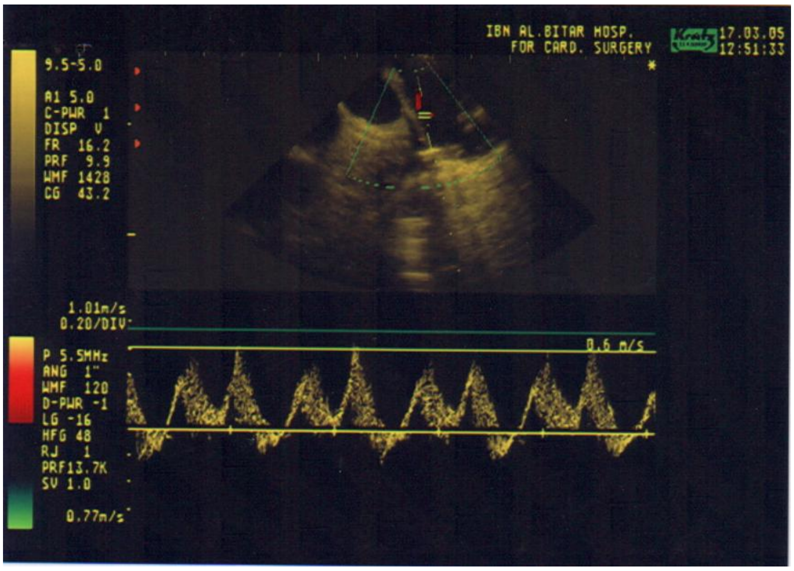

Fig. 2: PVF pattern in patient with hemodynamically significant secondum after ASO.

This difference dissipated after ASD closure (0.42±0.32 m/s vs 0.48±0.15 m/s, p=0.32, table 2.

After ASD occlusion, 62 patients had biphasic PVF pattern, while a monophasic pattern persisted in 2 patients (table 3). The peak PVF velocity dropped significantly in the 62 patients who ended up with a biphasic flow pattern after ASD occlusion (0.73±0.19 m/s vs 0.46±0.15 m/s, p<0.0001, table 3). In contrast, the two patients with persistent monophasic pattern failed to drop their PVF velocity immediately after ASO deployment (1±0.07 m/s to 0.9±0.14 m/s, P=0.2, table 3). Additionally, the 2 patients who retained a monophasic pattern following ASD occlusion got residual shunts (table 3).

The majority of patients with residual shunts failed to drop the peak PVF velocity by ≥ 30%, whereas those patients without residual shunts had significantly higher magnitude of drop of PVF velocity (table 4).

Table 3: The relation between residual shunt and the change in pattern of PVF

	PVF pattern before and after ASO			Total number
	B→B No (%)	M→B No (%)	M→M No (%)	
All patients	7 (10.9)	55 (85.9)	2 (3.1)	64
Patients with residual shunts	1 (8.3)	9 (75)	2 (16.7)	12
Patients with no residual shunts	6 (11.5)	46 (88.5)	0 (0)	52

Table (4): classification of the percentage of reduction in PVF velocity and its relation to the presence or absence of residual shunt

		Difference %				Total	P value
		0-29		30-			
		No.	%	No.	%	No.	
Residual shunt	**No**	18	34.6	34	65.4	52	0.04*
	Yes	8	66.7	4	33.3	12	

*Significant difference

Discussion

This study characterized by focusing on 3 points:
1-PVF peak velocity.
2-PVF pattern.
3-Presence or absence of residual shunt .

Complete closure of ASD was achieved only in 81.25% of patients. This study found a simple method to make the operator aware about the presence of residual shunt by measurement of PVF velocity before and after ASO deployment.

In this study, there were more than 10% of patients with hemodynamically significant secondum ASD had biphasic pattern, and it was showed that these patients got peak PVF velocity significantly less than patients with monophasic pattern. This means that the unique monophasic pattern may due a combined effect of both factors (i.e. the presence of the defect and the amount of PVF velocity), although Hoffman et al found that monophasic pattern was found in the 12 (30%) patients with elevated right ventricular systolic pressure (RVSP) (35-69 mmHg) with increased velocities and accompanied by forward flow during atrial systole, in addition to the maintenance of forward flow from LUPV into the left atrium throughout the whole cardiac cycle (including atrial systole) which is confirmed by synchronized Doppler profiles of the flow through the defect and through the LUPV. ASD constitutes the additional outlet of the flow from within the left atrium and precludes elevation of left atrial pressure with subsequent LUPV flow reversal, invariably present in normal subjects[3].

No significant effect of age and ASD size on the pattern was found.

In this study, pre-occlusion peak velocity detected was 1.3 m/s, minimum was 0.4 m/s, mean velocity; 0.74±0.19 m/s. So there was great overlap between normal values and values in patients with secondum ASD. So depending solely on the normal range as a guide for successful occlusion is non-practical.

Of note is; in this study, the mean PVF velocity post-occlusion was 0.48±0.16m/s with significant reduction in velocity by 34.82% (P value = 0.0001).

There was significant difference in mean peak velocity after ASO between patients with bi- and monophasic patterns. This may point to the importance of PVF velocity in the creation of the unique monophasic pattern in secondum ASD. Although there was significant reduction in PVF velocity after ASO in both groups, there was no significant difference neither in the resulted mean velocity nor the percentage of reduction between both groups (biphasic; 0.42±0.23 with 30.41% reduction, monophasic; 0.48±0.15 with 35.37% reduction).

There were only 2 patients with monophasic pattern after ASO, and both got mean reduction by only 10.27% in PVF velocity. This significantly differed from remainder 62 patients with biphasic pattern who got reduction by 35.62%. This signifies the importance of the PVF pattern post-occlusion.

Regarding the residual shunt; the residual shunt ranged between trivial to moderate, but we didn't record the severity of the shunt because there were some technical problems regarding quantitative measurement. Also we noticed the relation of the residual shunt with the PVF velocity relatively late in the study because of the small sample volume.

This study showed the importance of recording PVF velocity before and after ASO as indirect sign for the presence of residual shunt. Hence, this study tried to find a simple quantitative method to identify the presence of significant shunt depending on the percentage of reduction of PVF velocity after ASO, and found that reduction by 30% and more significantly related with the absence of residual shunt.

This study concludes the following:

1-Both the defect in ASD and the amount of PVF velocity cooperate in the creation of the monophasic pattern.

2-The presence of monophasic PVF pattern signifies the presence of ASD with significant left-to-right shunt.

3-Neither the presence of biphasic PVF pattern nor PVF velocity within the normal range excludes presence of hemodynamically significant ASD.

4-PVF pattern and velocity pre- and post-occlusion is an important guide to a successful occlusion of an ASD.

So we recommend:

1-The use of PVF pattern and velocity by Doppler echocardiography in every patient with secondum ASD before and after ASO.

2-The need for further studies in this field with accurate quantitative measurement of residual shunts if any, and its relation to the PVF pattern and velocity.

3-Further studies required to evaluate the PVF pattern and velocity in other cardiac problems with left-to-right shunt.

References

1-Klein AL, Burstow DJ, Tajik AJ, Zachariah PK, Bailey KR, Seward JB. Effects of age on left ventricular dimensions and filling dynamics in 117 normal persons. Mayo Clin Proc. 1994 Mar; 69(3):212-24.

2-Munagala VK, Jacobsen SJ, Mahoney DW, Rodeheffer RJ, Bailey KR, Redfield MM. Association of newer diastolic function parameters with age in healthy subjects: a population-based study. J Am Soc Echocardiogr. 2003 Oct;16(10):1049-56.

3-Hoffman et al. Left Upper Pulmonary Venous Flow Pattern in Adults with Ostium Secondum Atrial Septal Defect and Significant Left-To-Right Shunt. Polish Heart Journal; vol I-III.

4-Saric et al. Pulmonary Venous Flow in Large Uncomplicated Atrial Septal Defect. J Am Soc Echocardiogr 2001 May; 14 (5): 386-90.

5-Chockalingam, et al. Role of Transthoracic Doppler Venous Flow Pattern in Large Atrial Septal Defects. Echocardiography 2005 Jan; 22 (1), 9-13.

6-Levin A, Spach MS, Boineau JP, Canet RV: Atrial pressure flow dynamics in atrial septal defects (secondum type): Circulation; 1968, 37, 475-488.

7-Rakowski H, et al: Canadian consensus recommendations for the measurement and reporting of diastolic dysfunction by echocardiography. J Am Soc Echocardiogr 1996; 9: 745-764.

8-Terence D. Basics of Transesophageal Echocardiography. Churchill Livingstone 1995; 86.

9-G Fischer et al. Experience with transcatheter closure of secondum atrial septal defects using the Amplatzer septal occluder. Heart2003; 89: 199-204.

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