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Real-Time Three-Dimensional Echocardiography in Percutaneous Transcatheter Closure of Atrial Septal Aneurysm with Atrial Septal Defect in Pediatrics

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ABSTRACT

Background: ASA (atrial septal aneurysm) is redundant and mobile atrial septum. It accounts for 2-3% of population.

Aim: This study aims to evaluate the use of echocardiographic guidance in percutaneous closure of ASA.

Methods: It is a prospective cohort design on 60 ASD secondum children who were referred for transcatheter closure between february 2022 to february 2024 at catheterization labs of Tanta Teaching University Hospital, Tanta New Surgical Hospital and Alexandria Smouha Children University Hospital.

Results: Only 14 ASD cases were ASD with ASA and all underwent percutaneous closure successfully with different closure techniques with no risk of complications and deployment was done smoothly under three-dimensional echocardiography.

Conclusions: Three-dimensional echocardiography can help in closure of secondum ASD with ASA in children.

Keywords: *atrial septal aneurysm, transcatheter, echocardiography, fluoroscopy, transesophageal.*

1. INTRODUCTION

Atrial septal aneurysm (ASA) is a congenital disruption of interatrial septum consisting redundant and mobile interatrial septal part in the region of fossa ovalis with bulging into right or left atrium and oscillating between both atria.[1] Prevalence of ASA is 2-3% in adult population. ASA is diagnosed when it moves more than 10 mm in either direction from septal plane or more than 15 mm total excursion between both sides [1] .The majority of patients with an ASA have a PFO. Typically, such a PFO is larger than a PFO without ASA.[2]

ASA is divided into 2 groups: fixed ASA (46%) including types 1R and 2L which only bulge within an atrium and mobile ASA (54%) include types 3RL, 4LR, and Type-5 which bulge bidirectionally into both atria). [3] ASA may be isolated or associated with another anomaly. The commonest association is PFO, ASD, mitral valve prolapses, tricuspid valve prolapses, Marfan syndrome and sinus of Valsalva aneurysm. Shunt across ASA is more accurately assessed with TEE than with TTE.[4]

ASA may be as a possible source of arterial embolism by thrombi formation either within, on the ASA or passage of thrombi through defect. The potential risk of temporary supra ventricular arrhythmias may be another cause of embolism.[5]

2. METHODS

Study design and sample size

This is a longitudinal cohort study conducted 14 children from all 60 ASD secondum children who were referred for transcatheter closure between february 2022 to february 2024 at catheterization labs of Tanta Teaching University Hospital and Alexandria Smouha Children University Hospital.

Patient selection

Written informed consent was obtained from the parents of the children who participated in this study. The study was conducted in accordance with ethical approval granted by the Local Ethical Committee of Tanta Faculty of Medicine, under approval code 35271/2/22. The caregivers provided informed written consent.

Inclusion criteria

Pediatric aged between 2 and 18 years with haemodynamically significant ASD secundum with ASA.

Exclusion criteria

Children with complex congenital heart diseases, pediatric patients less than 10 kgs and various types of ASD not amenable for transcatheter closure were all excluded from the study.

Echocardiographic assessment

All participants underwent 2D TTE with Philips EPIQ CVx (Philips Healthcare, Washington, USA) or Vivid E95 Echocardiography ultrasound machine (GE Healthcare, Horton, Norway) equipped with X matrix probe and software package including 3D data acquisition and analysis.

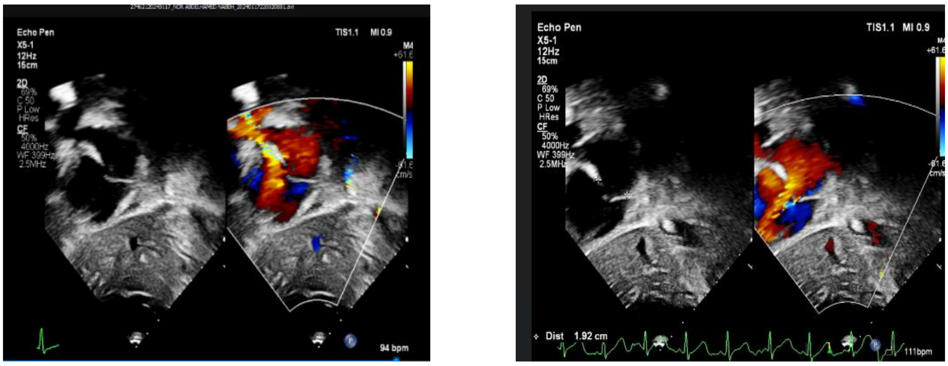
Conventional 2D TEE

Mid-esophageal four-chamber (ME 4C) view, mid-esophageal aortic valve short-axis (ME aortic SAX) view and mid-esophageal bicaval view were acquired from the mid-esophageal position using multiplane angles of 90°, 105°, and 120°.

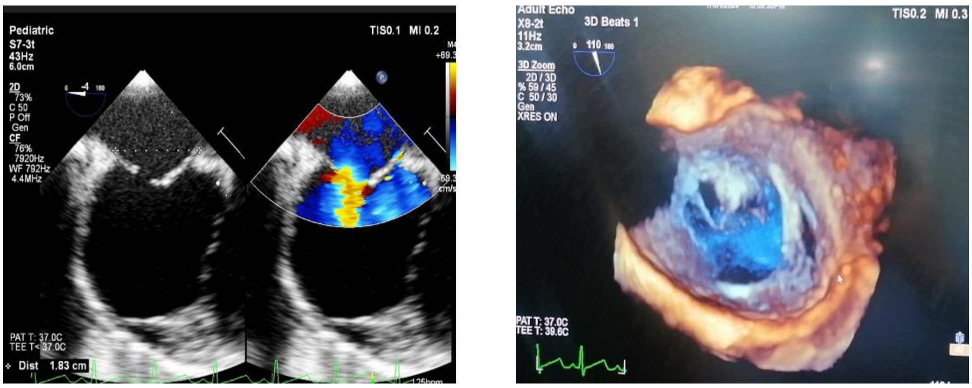
Three-dimensional transesophageal echocardiography (3D TEE)

Only in children above 20 kgs body weight (as 3D TEE prob is larger), After completing the 2D TEE, some cases whose body weight allows 3D TEE prob were subjected to 3D TEE using the same Vivid E95 machine or Philips EPIQ CVx. The 3D TEE was further superior to 2D TEE as it provided all the needed information in a single view, which otherwise took a series of 2D TEE views, preparations for 3D TEE imaging started with the acquisition of good 2D TEE images of the interatrial septum.

While evaluating the IAS using; live 3D TEE and 3D zoom of IAS from several key views were performed. We used RATLe-90 "Rotate-Anticlockwise-Tilt Left for 90 degrees" maneuver as shown in figure 1.



Sagittal view of ASD showing 2 ASD secondum (2D TTE)



2D and 3D TEE assessment showed it is ASA with multiple fenestrations (3D assessment showed more than 3 fenestrations)

Figure (1): ASD assessment using different echo modalities (2D TTE and 2D/3D TEE).

3. RESULTS

Fourteen children were atrial septal aneurysm with ASD and we thought they were amenable for percutaneous closure.

Table (1): Comparison between total aneurysm dimensions by 2D and 3D TTE among ASA patients

	ASA				Test of Sig	P
	2D TTE (n = 12)		3D TTE (n = 12)			
	No.	%	No.	%		
Minimal diameter						
Mean ± SD.	16.33 ± 5.61		17.25 ± 5.46		Z= 1.884	0.060
Median (Min. – Max.)	15.0(10.0 – 26.0)		15.50(11.0 – 27.0)			
Maximal diameter						
Mean ± SD.	18.83 ± 5.70		20.08 ± 6.42		Z= 1.764	0.078
Median (Min. – Max.)	16.50(11.0 – 28.0)		17.50(13.0 – 34.0)			

Table (2): Comparison between total aneurysm dimensions by 3D TTE and 2D TEE among ASA patients

	ASA				Test of Sig	P
	3D TTE (n = 14)		2D TEE (n = 14)			
	No.	%	No.	%		
Maximal diameter						
Mean ± SD.	20.08 ± 6.42		20.0 ± 6.32		Z= 1.000	0.317
Median (Min. – Max.)	17.50(13.0 – 34.0)		17.50(34.0 – 34.0)			

Table (3): Comparison between total aneurysm dimensions by 2D and 3D TEE among ASA patients

	ASA				Test of Sig	p
	2D TEE (n = 14)		3D TEE (n = 14)			
	No.	%	No.	%		
Maximal diameter						
Mean ± SD.	19.86 ± 5.67		19.99 ± 5.04		Z= 1.000	0.317
Median (Min. – Max.)	19.0(13.0 – 29.0)		19.0(13.0 – 28.0)			

They show no significant difference between both modalities as regarding maximal dimension and in 3D TTE and 2D TEE and 2D TEE, 3D TEE as well (Table 1, 2, 3).

Table (4):Comparison between the additional fenestrations and shape detected by 2D and 3D TTE among ASA patients

	ASA				Test of Sig	p
	2D TTE (n = 14)		3D TTE (n = 14)			
	No.	%	No.	%		
Associated fenestrations						
No	1	8.3	0	0.0	MH=	0.009*

1	1	8.3	1	8.3	31.50*	
2	4	33.3	2	16.7		
3	6	50.0	1	8.3		
>3	0	0.0	8	66.7		
Shape						
Not clear	0	0.0	1	8.3	MH= 22.50	0.362
Irregular	7	58.3	0	0.0		
Oval	3	25.0	9	75.0		
Round	2	16.7	0	0.0		
Cone	0	0.0	2	16.7		

ASA children were evaluated by 2D and 3D TTE, there was no significant difference between 2D and 3D TEE as regarding shape. However, there was statistically significant difference between both as regarding detection of associated fenestrations (P-value =0.009) (as 3D TTE detected more associated fenestrations compared to 3D TTE) (Table 4).

Table (5): Distribution of the studied cases according to Device

	No.	**%**
Type		
ASO	1	7.1
PFO	13	92.9
Company		
Amplatzer	14	100.0
Ocuulotech	0	0.0
Device size		
Min. – Max.	18.0 – 40.0	
Mean ± SD.	27.79 ± 7.01	
Median (IQR)	27.50(25.0 – 35.0)	

Table (6): Distribution of the studied cases according to 2D TTE measurements

	No.	**%**
RVEDD		
Normal	0	0.0
Dilated	14	100.0
ESPAP		
Min. – Max.	28.0 – 50.0	
Mean ± SD.	40.21 ± 5.87	

Median (IQR)	39.50(37.0 – 45.0)
TAPSE	
Min. – Max.	1.50 – 3.0
Mean ± SD.	2.26 ± 0.47
Median (IQR)	2.15(2.0 – 2.60)

IQR: Inter quartile range SD: Standard deviation

RVEDD right ventricle end diastolic diameter

TAPSE tricuspid annular plane systolic excusion

It was found that right ventricle was dilated in all cases with estimated systolic pulmonary pressure (ESPAP) ranged from 28.0 – 50.0mmHg.

4. DISCUSSION

ASDs are known to have complex geometry that may be elliptical, ovoid, or multiple defects or fenestrations [6-7]. The 3DE provides more spatial anatomic information without the need for mental 2D reconstruction [8-9] and RT 3D TEE. In addition, some previous studies have demonstrated possible usefulness of 3D TTE for evaluating ASD morphology.[10]

Initially, TEE was used to supplement X-ray imaging in catheter guidance and intraoperative evaluation of cardiac surgery. In recent years, TEE has been found to be feasible for guiding transcatheter ASD closure in children.[11]

Assessment of ASD morphology and relationship with near-field structures was enhanced through the introduction of 3DE. [12] Initially, 3D measurements were complex, time taking and difficult to perform. Acquisition and post-processing were time consuming and not applicable during catheterization. [13]

Our results come in agreement with the published data by Saha et al. who reported statistically significant difference between the maximum diameter of the defect by 2D and 3D TTE (larger diameter with 3D TTE) with strong correlation of 2D/3D TTE with ASD and concluded that 3D TTE can replace balloon sizing technique in measuring ASD size. [14]

Furthermore, our results also come in agreement with Mani et al, who found a good agreement between 2D and 3D TEE for measured ASD diameters. [15]

Also, Van den Bosch et al. who demonstrated that RT 3D TTE enabled reliable assessment of the dimensions of ASDs and they reported an excellent correlation of RT 3D TTE findings compared with 2D TEE measurements of ASDs in pediatric and relatively young adult patients.[16]

Also, we disagreed with Deng et al who reported there was statistically significant difference in the maximal diameter by TEE with larger maximal diameter with 3D TEE compared to 2D TEE especially with oval and complex shaped ASD as in their study was larger sample size than our study, their patients were older in age and that permitted nearly all patients to do 3D TEE except only two patients excluded who have poor quality 3D images.[17]

Assessment of ASD morphology and relationship with near-field structures was enhanced through the introduction of 3DE [12] . Initially, 3D measurements were complex, time taking and difficult to perform. Acquisition and post-processing were time consuming and not applicable during catheterization. [13]

5. LIMITATIONS

Small sample size and short duration of follow up, Limitations of live 3D TTE (include patients must have an adequate acoustic window to permit an adequate 2D TTE exam, thin cardiac tissue in pediatrics with tachycardia make it is difficult to assess ASD with 3D TTE) and limitations of 3D TEE probe (needs at least body weight 20kgs) and that limits studies of 3D TEE in most of pediatric

6. CONCLUSION

Three-dimensional echocardiography can help in assessment of atrial septal aneurysm with ASD and guiding percutaneous closure.

Ethic approval: Faculty of Medicine, Tanta University. The study was conducted following approval by the Local Ethical Committee of our Faculty of Medicine, under ethical approval code 35271/2/22.

Conflict of Interest: The authors declare that they have no commercial affiliations—such as consultancies, stock ownership, equity interests, or patent/licensing arrangements—that could be perceived as potential conflicts of interest related to this manuscript.

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