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Three Dimensional Transesophageal Echocardiography versus Conventional Two Dimensional Transesophageal Echocardiography in Evaluation of Suitability of Atrial Septal Defect for Transcatheter Closure

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Abstract: Background: Atrial septal defect (ASD) is the most common acyanotic congenital cardiac defect, occurring in 0.1% of births. Transcatheter closure of ASD Secundum type is the preferred tool as long as the defect is amenable for closure. Three-dimensional (3D) transesophageal echocardiographic (TEE) imaging is used in ASD closures. 3D TEE imaging obviates the need for mental reconstruction of 3D structures from two-dimensional images. **Objectives:** The study was to evaluate the feasibility of 3D TEE versus two-dimensional (2D) TEE to select the patient's candidate for percutaneous closure and to guide the procedure up to the device deployment. **Methods:** This study was conducted on a number of thirty patients diagnosed with ASD secondum. Two dimensional TEE and Real time (RT) three dimensional TEE were done to confirm the suitability of ASD for transcatheter closure and repeated alternatively in the catheterization Laboratory before and during guiding the procedure. ASD size, site, rims, associated patent foramen ovale (PFO) and aneurysmal tissue and number of fenestrations within the associated aneurysm were compared by both tools. **Results:** by comparing the data obtained by 2D and 3D TEE, there was no significant difference between both as regard size and site of ASD, detection of associated PFO and aneurysm while 3D TEE was more superior in assessing the number of fenestrations within aneurysmal ASD. Both tools were nearly the same assessing the sufficiency of Aortic, Atrioventricular, posterosuperior rims while 3D TEE was more superior assessing the sufficiency of posteroinferior and posterior rims. **Conclusion:** RT 3D TEE as an adjunct to 2D TEE is a feasible and safe tool to guide transcatheter device closure of interatrial septal defects especially in challenging cases with complex ASD morphology. 3D TEE was further superior in assessing the fenestrations and posterior and posteroinferior rims.

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Key words: Atrial septal defect, Real time three dimensional transesophageal echocardiography, transcatheter closure.

1. Introduction

Transcatheter closure has become the standard treatment for an atrial septal defect (ASD).3D TEE is a promising modality to provide comprehensible en face images of ASD, especially in patients with a complex-shaped ASD and to guide the procedure of ASD transcatheter closure.(1, 2)

Real-time three dimensional transesophageal echocardiography (3D TEE) demonstrates the changing shape of the ASD during the cardiac cycle, used to observe the position of guide wires, sheaths, and devices in real time which cannot be seen accurately by two dimensional transesophageal echocardiography.(3, 4)

2. Patients and Methods:

This study was conducted on a number of 30 patients who underwent percutaneous trascatheter ASD secondum type closure guided by 2D/3D Transesophageal echocardiography, between April 2018 to April 2019 in Tanta University Hospital, Cardiovascular Department. All Patients included in the study were subjected to detailed history taking, full clinical examination, twelve leads surface Electocardiography, plain chest x-ray, routine laboratory investigations, full 2D transthoracic echocardiography, 2D transesophageal echocardiography and 3D transesophageal echocardiography.

Patients Selection for transcatheter closure:

Candidates for ASD closure have a hemodynamically significant atrial shunt or the presence of right ventricular volume overload and/or clinical symptoms of dyspnea, impaired exercise capacity, or paradoxical embolism.

Exclusion criteria:

Pediatric patients less than 18 kg for unsuitability of TEE probe, Patients with significant myocardial, valvualr, and/ or congenital heart disease where ASD was not the main cardiac morbididty responsible for the patients symptoms, Primum ASD, Venosus type of ASDs, Eisenmengers syndrome with right to left shunt through the secodum ASDs and Any pathology that may interfere with TEE study as Dysphagia, esophageal stricture, or varices.

Two-dimensional then Three-dimensional TEE studies for all patients were recorded with Vivid 9, General Electric Corporation using matrix array TEE probe, General Electric (GE) 6VT-D vivid 9 probe. Multiple and sequential TEE views were used to completely and systematically evaluate the interatrial septum, size, shape, site, rims of ASD, the relationship of the defect to its surrounding structures, presence of associated PFO, aneurysm and number of aneurysmal fenestrations.

Methods of analysis:

Analysis was done using flexi slice software and quantification system mostly on the echocardiography machine.

Three-dimensional TEE images were obtained in the following modalities: (1) biplane imaging (a side-by-side display of a pair of 2D TEE images), (2) full-volume imaging (several slices; each slice is acquired over one cardiac cycle; individual slices are stitched together and displayed in a delayed nonlive fashion), (3) narrow-angle live 3D imaging and (4) wide-angle 3D zoom imaging which appears to be the most useful 3D modality for visualizing the anatomy of the interatrial septum as it provides live images of almost the entire interatrial septum.

Transcatheter closure of ASD guided by RT 3D TEE:

Live 3D imaging, in the midesophageal view, was used to guide transcatheter closure of ASD.

Vascular access was obtained from the right femoral vein and, heparin (100 IU/Kg) and antibiotics (flucloxacillin 100 mg/Kg) were administered. A complete ASD evaluation was redone. The device was chosen according to the TEE maximum ASD diameter, considering the total interatrial septal length as the left atrial disc should be always less than the total interatrial septal length.

A multipurpose 6 French catheter was inserted in the left upper pulmonary vein or in the right upper pulmonary vein, then super stiff exchange wire (0-35) was wedged there. Over the wire we advance the long sheath with its dilator, the sheath was left at the mouth of the pulmonary viens. Then the dilator with the wire is withdrawn quickly allowing blood to pass down from the side port of the sheath without any injection into it to ensure absence of air bubble entry into the left atrium. During these steps the device is prepared, tipped in heparinized saline and connected to its wire (pusher) and is flushed very carefully under saline then passed through the short sheath into the long sheath and advanced under fluoroscopic guidance to the left atrium.

After that under fluoroscopic and TEE guidance simultaneously, the left atrial disc is pushed and the sheath is withdrawn until the left atrial disc opens completely and repositioned if needed on the left atrial side of the septum, then the sheath is withdrawn to open the right atrial disc.

During the placement of the device, the 3D zoom mode was subsequently used to image the interatrial defect using an en face view. 3D data set was rotated to allow simultaneous views from the right and left atrium. Deployment of the left atrial disc was monitored on-line using the 3D zoom mode.

Statistical analysis:

Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median.

3. Results:

There were 30 patients from April 2018 to April 2019 requiring percutaneous ASD device closures.

Patient demographics:

Regarding the **gender**: 10 patients (33%) of the study population were males and 20 patients (66%) were females and regarding the **age**: The age of the study population ranged from 7 to 60 years with a mean of 31.7 ± 14.4 years. Regarding the **weight**: The weight of the study population ranged from 22 to 91 kg with a mean of 65 ± 20.27kg.

Patient symptoms:

4 patients (13.3%) were asyptomatic,4 patients (13.3%) had recurrent respiratory tract infection, 22 patients (73.3%) had impaired exercise capacity.

Comparison between data obtained by 2D TEE and 3D TEE: As regard site:

There was no statistical significance between both tools with p value =1, where 9 patients had central ASD, 13 patients had eccentric anterior ASD and 8 patients had eccentric posterior ASD by both tools.

As regard size: there was also no statistical significance between both tools; 2D TEE shows mean maximum defect size 27.87 ± 6.6mm and 3D TEE shows mean maximum defect size 27.63 ± 6.37mm; p value= 0.199 which is non significant. (Table 1)

As regard associated PFO and aneurysm with ASD: There was complete agreement between 2D TEE and 3D TEE in detecting associated

PFO/aneurysm with p value =1, where 9 patients had PFO and aneurysmal tissue associated with ASD and 6 patients had aneurysmal ASD only.

As regard fenestrations within the aneurysmal tissue associated with ASD: 3D TEE was more superior than 2D TEE in detecting the number of fenestrations accurately, where 2D TEE detected only 2 patients with multiple fenestrations, while there was actually 12 patients with multiple fenestrations as detected by 3D TEE with kappa value = -0.017 and p value =0.019 which is statistically significant. (Table 2, Fig 1)

Table 1: Comparison between maximum ASD size by 2D TEE and 3D TEE

	TEE (2D) Mean ± SD	TEE (3D) Mean ± SD	T	P Value
Max defect diameter in mm	27.87 ± 6.6	27.63 ± 6.37	1.316	0.199

Table 2: Number of fenestrations by 2D TEE and 3D TEE.

		Fenestrations (TEE 3D) n=(15)			Kappa Value	P Value McNemar
		No n=(1)	Two n=(2)	Multiple n=(12)		
Fenestrations (TEE 2D) n=(15)	No n=(2)	0	1	1	-0.017	0.019
	Two n=(11)	1	1	9		
	Multiple n=(2)	0	0	2		

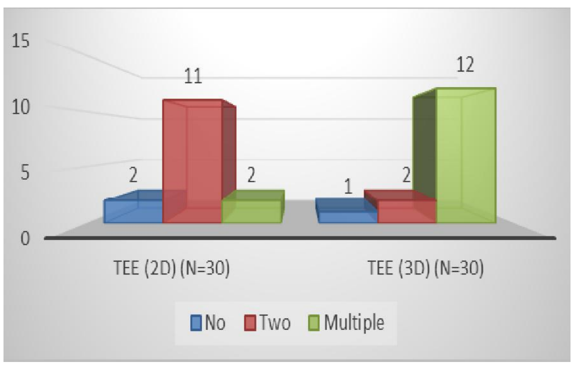

Figure 1: Comparing the number of fenestrations as detected by 2D TEE and 3DTEE.

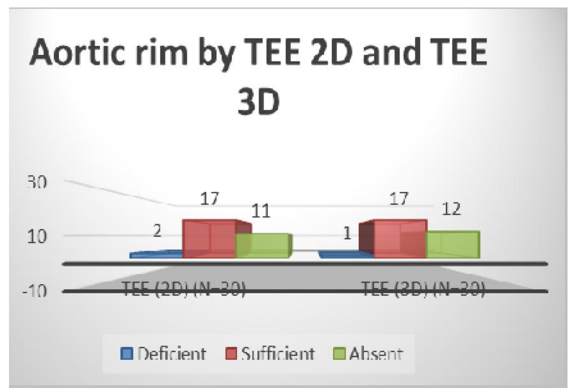

Figure 2: Comparing Aortic rim sufficiency by 2D and 3D TEE.

Asregard the rims: There was no statistical significance between 2D and 3D TEE as regard assessment of rims sufficiency considering it is sufficient when ≥ 5mm.

Aortic rim: there was no statistical significance between both tools in detecting rim sufficiency with p value =0.26 (fig 2)

Atrioventricular rim: there was no statistical significance between both tools in detecting rim sufficiency with p value=1 as it was sufficient by both in 29 patients and deficient in only one patient.

posterosuperiorrim: Was sufficient as assessed by both 2D and 3D TEE in all the 30 patients of the study population.

posteroinferior rim: There was no statistical significance between 2D and 3D TEE with p value=0.25. 21 patients had sufficient IVC rim when assessed by 2D TEE while actually 24 patients had sufficient IVC rim when assessed by 3D TEE. (Table 3).

Table 3: Comparison between 2D and 3D TEE assessing the posteroinferior rim

		Patients of deficient IVC rim (TEE 3D) n=(30)		Kappa value	P Value McNemar
		Deficient n=(6)	**Sufficient n=(24)**		
Patients of deficient IVC rim (TEE 2D) n=(30)	**Deficient n=(9)**	6	3	0.737	0.25
	Sufficient n=(21)	0	21		

Posterior rim: There was no statistical significance between 2D and 3D TEE in assessing posterior rim with p value=0.125. 4 patients who revealed deficient posterior rim as assessed by 2D TEE were actually sufficient when assessed by 3D TEE. (Table 4)

Table 4: Comparison between 2D and 3D TEE assessing posterior rim

		Patients of deficient posterior rim (TEE 3D) n=(30)		*Kappa value*	*P Value McNemar*
		Deficient n=(6)	**Sufficient n=(24)**		
Patients of deficient posterior rim (TEE 2D) n=(30)	**Deficient n=(10)**	6	4	0.667	0.125
	Sufficient n=(20)	0	20		

Correlation between the device size and the maximum ASD size by both 2D TEE and 3D TEE:

There was a strong correlation between the device stent diameters and the ASD maximum diameter by 2D transesophageal echocardiography (r.= 0.939) and 3D transesophageal echocardiography (r. = 0.937). (Table 5)

Table 5: Correlation between the selected device size and maximum diameters of ASD by TEE 2D and TEE 3D, with R coefficient = 0.939 and0.937 respectively, pvalue<0.001 for both tests which means significant correlation.

	Maximum ASD diameter, TEE 2D (n=30)		Maximum ASD diameter, TEE 3D (n=30)	
	r	P	r	P
Device size	0.939	<0.001*	0.937	<0.001*

The procedure was successful in all 30 patients with no complications.

4. Discussion:

We have demonstrated that 3D TEE guidance was feasible and unlike 2D TEE, which relies on standard imaging planes, 3D TEE uses volume datasets. The 3D dataset can be cut into a multiple planes at any time in the cardiac cycle after acquisition.(5)

3D TEE was further superior to 2D TEE as it provided all the needed information in a single view, which otherwise would take a series of 2D TEE views, leading to inter- and intraobserver variation in assessment of the ASD.(6)

In our study, There was no statistical significance as regard the rims assessment between both 2D TEE and 3D TEE, as shown previously in the statistical analysis of our results But we think that if the same study was done on larger scale of patients, we may obtain statistical difference as regard posteroinferior and posterior rims as 3 patients who appeared with deficient IVC rim by 2D TEE were actually sufficient when assessed by 3D TEE and closed successfully. (7)

And 4 patients who revealed deficient posterior rim as assessed by 2D TEE were actually sufficient when assessed by 3D TEE. This is also agreed with Vinay K Sharma who reported 3D TEE is better in assessing the rims than 2D TEE. (8)

3D TEE in our study proved to be superior to 2D TEE in detection of the fenestrations and their number. The use of RT 3D TEE presented high-quality 3D images of the heart for on-line monitoring of the procedure, allowing safe device deployment. (9, 10)

Study limitations:

The current study had the following limitations:

1. The results were from single medical center (Tanta University Hospital).

2. The sample size was rather small.

Conclusion:

RT 3D TEE as an adjunct to 2D TEE is a feasible and safe tool to guide transcatheter device closure of interatrial septal defects especially in challenging cases with complex ASD morphology.

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