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RESEARCH ARTICLE

OUTCOME OF ASD CLOSURE WITH DEVICE SIZE BASED ON PRE PROCEDURE 3D TRANSTHORACIC ECHOCARDIOGRAPHY MEASUREMENTS AND ITS COMPARISON WITH 2D TRANSTHORACIC AND 2D TRANSESOPHAGEAL ECHOCARDIOGRAPHY: AN OBSERVATIONAL ANALYSIS AT A TERTIARY CARE HOSPITAL IN JAIPUR

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Abstract

Introduction: For safe percutaneous ASD device closure, the rims surrounding the defect should be appropriate to allow the device to firmly hang onto the atrial septum. Two-dimensional transthoracic echocardiography (2D TTE) is adequate in detecting these defects, but the images obtained can lack the detail necessary to precisely measure their size, shape, and location. Three-dimensional transthoracic echocardiography (3D TTE) provides enhanced visualization of the defect in the majority of patients. The primary objective of the study is to estimate the proportion of cases where device was deployed safely as per the device size predetermined by pre procedure 3D TTE and to compare it with current gold standard imaging modality, ie, 2D TEE.

Materials & methods: This single center observational study included 45 consecutive patients diagnosed as ostium secundum ASD by transthoracic echocardiography who were referred to SMS Hospital, Jaipur from March 2018 to September 2019. Patients included in the study, were examined by 2D and 3D TTE to determine the shape of the defect and visualize the surrounding structures before catheterization. Procedure performed under 2D TEE guidance, after measurement of defect size and surrounding tissue rims in the cath lab. Follow-up using 2D TTE and 3D TTE performed 24 hrs and 3 months after the trans-catheter ASD closure.

Results: Trans-catheter ASD closure and echocardiographic examinations were successfully performed for all patients. No significant difference between the sizes of different rims by the three techniques (2DTTE vs 2DTEE vs 3DTTE). The ASD size by 3D TTE ranged from 14- 33 mm with a mean of 23.27 ± 4.91 mm and the ASD size by 2D TEE ranged from 11-32 mm with a mean of 21.73 ± 4.99 mm. While ASD size by 2D TTE ranged from 12-30 mm with a mean of 20.26 ± 4.55 mm. There was statistically significant difference between the maximum ASD diameter measured by 2D/ 3D TTE and that by 2D TEE ($p = 0.013$), with 3D TTE showing larger ASD diameter than 2D TTE/ 2D TEE resulting in larger predetermined size for ASD device closure. The assessment of the device relation to the aortic-mitral continuity, superior vena cava (SVC) and inferior vena cava (IVC) by 2D and 3D echocardiography was done at 24 hours and three months. Seven patients had mitral regurgitation; none had more

than mild mitral regurgitation. After the ASD closure, two devices were close to the SVC and one device was close to the IVC. Sixteen devices were close to the MV with mild regurgitation in three of them; two were newly detected and one with previous mitral regurgitation. Twelve devices were close to the aortic rim without regurgitation. There is no major complication in any patient on follow up.

Conclusion: Predetermination of ASD closure device size is possible and safe with 3D TTE. 3D TTE is a safe and non-invasive strategy as compared to 2D TEE for deciding about suitability of device closure with sufficient rims. This may be useful in patients in whom TEE could not be done, especially in pediatric population.

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Introduction:-

Atrial septal defects (ASDs) account for approximately 13% of congenital heart disorders, with a prevalence ranging from 1.6 to 1.8 of 1000 live births and is comprised of 5 major types of atrial septal defects (ASDs), including Ostium primum type, Ostium secundum type, coronary sinus defect, sinus venosus defect, and patent foramen ovale (PFO). Secundum defects are the most common type of ASDs, and classically involve the middle portion of the interatrial septum but can occur in other areas of the IAS and result from either excessive absorption of the septum primum or arrested growth of the septum secundum.

The use of transcatheter device techniques for ASD closure has become widely accepted as an alternative therapy to surgery. Device closure is much safer and advantageous compared to surgery [1]. Only ostium secundum ASDs are amenable to percutaneous transcatheter closure. Ostium secundum ASD have six defined rims of tissue surrounding them (AV, Aortic, SVC, Superior, Posterior and IVC rim in continuity counterclockwise) (Figure 1).

For safe percutaneous ASD device closure, the rims surrounding the defect should be appropriate to allow the device to firmly hang onto the atrial septum. An ostium secundum ASD rim of less than 5 mm (except aortic rim) is considered deficient for purposes of transcatheter closure but does not represent an absolute contraindication to the procedure. The device should not be deployed if there are concerns about drainage from coronary sinus, vena cava or pulmonary veins, or if there is interference with the function of the atrioventricular valve [2].

The device size is currently chosen according to the maximum ASD diameter measured by 2D TEE. To avoid oversizing, recommendation is not to use devices larger than 1.5 times of ASD diameter [3]. The device stent diameter is 1.2–1.5 times the maximal defect diameter provided that the left atrial disc should be always less than the total atrial septal length [4]. The stop-flow technique should be used when balloon sizing of the ASD is done [5].

However, it is conceded that in some patients who have thin flailing septum primum, balloon sizing may not be easy because the septum is stretched even by gentle inflation of the balloon. Reported erosion of the aortic wall by the Amplatzer device with development of aorta-to right atrium [6] or aorta-to-left atrium [7] fistulae is the basis of the idea of oversizing the device (4 mm larger than the measured stretched diameter) in large defects with deficient aortic rim. This is meant to ensure that the device disks straddle and remain flared around the ascending aorta to prevent discrete areas of pressure where erosion may occur. Obviously, when over-sizing the device, care must be taken not to interfere with valve function and/or venous return [8].

Two-dimensional echocardiography (2DE) is adequate in detecting these defects, but the images obtained can lack the detail necessary to precisely measure their size, shape, and location. This is most pronounced when assessing the multiple holes or Swiss cheese pattern, in which these limitations become more evident.

Three-dimensional transthoracic echocardiography (TTE) provides enhanced visualization of the defect in the majority of patients. The ability to record, to analyze the entire cardiac structure and to display complex spatial relationship are potential advantages of 3D imaging over 2D echocardiography. 3D examination is a potential useful tool in studying the ASD device and its points of contact or pressure. Accordingly, the aim of this current work is to focus on the relation of the ASD devices to the aorta and aorticmitral plane using three- dimensional echocardiography.

Aims And Objectives:-

The primary objective of the study is to estimate the proportion of cases where device is deployed safely as per the device size predetermined by pre procedure 3D TTE. Secondary objectives are to determine the difference in mean size of ASD and its surrounding rims as detected by pre procedure 3D TTE, 2D TTE and 2D TEE; and also to determine the difference in mean ASD size, its rims and device size in cases with and without safe deployment of ASD device.

Materials and Methods:-

This single center observational study included 45 consecutive patients diagnosed as ostium secundum ASD by 2D TTE who were referred to SMS Hospital, Jaipur from March 2018 to September 2019.

Inclusion criteria:

Patients were included in the study and considered for transcatheter closure of ASD if patients have clinical symptoms, signs of RV volume overload and have suitable rims and defect size for ASD device closure and patients who sign informed consent before the procedure.

Exclusion criteria:

Patients not having isolated ostium secundum ASD by 2D TTE (multiple defects), patients with small ASDs with no symptoms or no signs of RV volume overload, severe PAH and bidirectional or R to L shunt, patients not having suitable rims (<5 mm except aortic rim) and defect size (>38 mm) for ASD device closure or patients with defect too close to SVC, IVC, pulmonary veins, AV valves or coronary sinus, were excluded from the study. Also patients with abnormal pulmonary venous drainage, associated congenital abnormality requiring cardiac surgery, who do not sign informed consent before the procedure and patients with any contraindication for TEE, were excluded.

Methodology:-

Patients included were examined by 2D and 3D TTE to determine the shape of the defect and visualize the surrounding structures before catheterization. The examination was done with commercially available Philips Epic ultrasound machine with X5-1 xMATRIX array transducer. Two crucial parameters were measured to select patients for transcatheter ASD closure. First parameter was the maximal defect diameter chosen and the selected device was usually 1.2 times larger than the largest ASD diameter if there was no aortic rim deficiency, while it was 1.3 times larger in aortic rim deficiency. The second parameter was the tissue rim dimensions all around the defect to optimize the placement of the device. ASD closure was done with the predetermined size of ASD closure device based on 3D TTE findings.

To achieve the highest resolution of the atrial septum and adjacent structures, a “full-volume” 3 dimensional (3D) dataset was obtained over 4 cardiac cycles. For transthoracic 3D images, the Apical 4 chamber view was taken. Real-time 3D imaging demonstrates the changing shape of the ASD during a cardiac cycle, with maximum size in diastole. To adjust the full volume, the echocardiography machine displays two adjacent 2D images showing two perpendicular planes of the data about to be acquired. The left plane is the coronal plane of the data which corresponds to the 2D echocardiography image when using the same probe position. The full volume was named after this coronal plane. The right plane is the sagittal plane showing the antero-posterior display of the data in the full volume. This plane was used to ensure the inclusion of all the data needed from a specific full volume.

Once acquired, these full volume data sets were analyzed immediately at the bedside and stored for later analysis. Analysis was done off line using the Q-lab software and quantification system mostly on the echocardiography machine. Analyzing the volume rendered data using cropping to show the structure of interest was the main method of describing the segmental approach of each patient. The data was collected to visualize the ASD, identify its relation to the surrounding structures, assessment of ASD regarding the shape and the dimensions, and the surrounding rims, the number of ASDs or multiple fenestrations and the relation of the device to the surrounding structures.

ASD device closures were performed under 2D TEE guidance, after measurement of defect size and surrounding tissue rims in the cath lab. Follow-up using 2D TTE and 3D TTE was performed 24 hrs and 3 months after the transcatheter ASD closure. After ASD closure, the relation of the device to the valves and vessels and if any residual flow was described.

Statistical analysis:

Continuous data are summarized in form of mean & SD. Difference in means of 2 groups is analyzed using Student's 't' test and difference in means of 3 groups is analyzed using ANOVA test. Count data are summarized in form of proportions. Difference in proportions is analyzed using Chi Square test. Proportion of cases where device is deployed safely as per the device size predetermined by pre procedure 3D TTE, is analyzed. The level of significance is kept 95% for all statistical analysis. P value is significant if <0.05 .

Results:-

Transcatheter ASD closure and echocardiographic examinations were successfully performed for all patients. Patient's demographic data and ASD measurements are presented in Table 1. All the patients had single implanted device; Lifetech ASD occluder in 29 patients (64.44%) and Cocoon ASD occluder in 16 (35.56%) patients. The sizes of the occluder device ranged from 18- 40 mm. Complications such as arrhythmia (1st degree heart block) were reported in two patients.

Comparison of different echocardiographic assessment techniques (2D

TTE/ 2D TEE/ 3D TTE) prior to ASD device closure:

1. **Sizes of different rims:** There is no significant difference between the sizes of different rims by the three techniques. (Table 2).
2. **ASD shape and size:** The ASD shape is well delineated by the 3D TTE performed after full volume data acquisition and cropping. All the defects are rounded except six patients had oval ASDs. There is no significant difference in the ASD shape assessed by 2D TTE and 3D TTE (6 by 3D TTE vs 7 by 2D TEE). The ASD size by 3D TTE ranged from 14- 33 mm with a mean of 23.27 ± 4.91 mm and the ASD size by 2D TEE ranged from 11-32mm with a mean of 21.73 ± 4.99 mm. While ASD size by 2D TTE ranged from 12-30 mm with a mean of 20.26 ± 4.55 mm. There is statistically significant difference between the maximum ASD diameter measured by 2D/ 3D TTE and that by 2D TEE ($p = 0.013$), with 3D TTE showing larger ASD diameter than 2D TTE/ 2D TEE.
3. **The required parameters for ASD device size selection:** The mean value of the whole atrial septal length is 45 ± 5.41 mm, ranging from 32 to 57 mm while the mean value of the left atrial device disc size is 42.53 ± 5.89 mm ranging from 25-47 mm. According to the Review Board and AGA Medical, the oversized device is defined if its size exceeds
4. 1.5 times the TEE/ICE diameter of ASD [3]. It was previously published that the device should be visualized by 3D echo after one month of deployment and its relation to the aortic mitral continuity plane should be noted [9]. In current study, significant oversized device is observed in 4 patients and the accuracy of this ratio came out to be only 60% (Table 3). The ASD device proximity to the aortic mitral plane is affected by ASD size, AV rim size (by 2D TTE/TEE & 3D TTE), posterior rim (by 2D TTE & 2D TEE), device size, left atrial disc and the ratio of the left atrial disc to the total interatrial septum length and a significant correlation is found between these variables by a multivariate analysis (table 4). The ASD size, AV rim size, posterior rim size and the left atrial disc size directly influenced the selection of the device size to avoid the oversizing and the encroachment on the aortic mitral continuity.
5. **Follow-up of the patients:** The assessment of the device relation to the aortic-mitral continuity, superior vena cava (SVC) and inferior vena cava (IVC) by 2D TTE and 3D TTE was done at 24 hours and three months. 7 patients had mitral regurgitation; none had more than mild mitral regurgitation. After the ASD closure, two devices were close to the

SVC and one device was close to the IVC. 16 devices were close to the MV with mild regurgitation in 3 of them; two were newly detected and one with previous mitral regurgitation. 12 devices were close to the aortic rim without regurgitation. There is no major complication on follow up of any patient.

Discussion:-

With progressive experience with transcatheter device closure, device size is gaining more attention rather than success alone, as too large devices are prone for mushroom deformities, encroaching cardiac structures and possible serious complications as cardiac erosions. [10]. 2D TEE is currently the standard method to assess the ASD size [11, 12]. Three-dimensional echocardiography is currently being used to show the morphology of the defect, this questioned the accuracy of 2D TEE in shape determination.

A survey was done in 2004 showed that patients with deficient aortic rims were noted in 90% of patients with erosion. The devices with lower risk of erosion are those that straddle the aorta, are somewhat oversized and don't move relative to the heart, while the devices with higher risk are those with protruding left atrial disc into the aortic root, are somewhat undersized and may have motion relative to adjacent heart structures [13]. In the current study, 3D TTE is used for the selection of the appropriate device size with the selected device usually 1.2 times larger than the largest ASD diameter if there is no aortic rim deficiency, while it was 1.3 times larger in aortic rim deficiency.

In one study, Morgan et al. compared parameters obtained from 2D TEE to 3D TTE. Although the differences in measuring the defect's circumference, area, and diameter was not statistically significant when comparing the two imaging studies, it was clinically significant, showing that 3D TTE was just as accurate in its ability to recognize appropriate candidates for percutaneous closure of ASDs, thereby reducing the need for the more invasive TEE procedure and bypassing its major complications such as gastrointestinal bleeding, esophageal hematoma formation, and perforation. In current study, the ASD size by 2D TEE examination ranged from 11–32 mm with a mean of 21.73 ± 4.99 mm while ASD size by 3D TTE ranged from 14–33 mm, with a mean of 23.27 ± 4.91 . There is statistically significant difference between these measurements by both techniques ($P < 0.001$) with 3D TTE showing larger ASD diameter than 2D TEE resulting in larger predetermined size for ASD device closure.

The definition of an oval shaped ASD is used when the ratio of the shortest diameter to the longest diameter < 0.75 [14]. In our cohort, there is no significant difference between 3DTTE and 2DTEE in relation to the shape determination.

Watanabe and his coworkers [15] studied the morphology and the defect differences by 3D TTE and 2D TTE. The right parasternal approach was obtained for 88 patients (80.0%) to assess ASD morphology. Although there was a significant difference in the maximal ASD diameter by comparing the conventional left approach to transesophageal echocardiographic measurements ($P < 0.05$). When the right parasternal approach was applied, a significant difference was not found ($P = 0.18$) [15], and the diagnostic concordance of the rim deficiency was improved from 85.2% to 90.9%. Three-dimensional TTE from the right parasternal approach improved visualization of the ASD shape and location from 65.5% to 74.5%.

Based on the review board and AGA medical reports [3], the erosions caused by the device are related to the oversizing, and their recommendation was not to use device more than 1.5 times ASD diameter measured by TEE/ICE. Upon this recommendation, 3DTTE to 2DTTE relationship concerning 1.5 times of the defect size showed an accuracy of only 60%.

The above mentioned data directed us towards 3D TTE to find the relation of the aortic-mitral continuity plane to the selected device size through various parameters. The device tends to be displaced towards the aortico-mitral plane (direction of blood flow) due to continuous forces: 1- The gravity 2- weight of the device 3- Drag and friction drag which depend on the thickness of the device (friction drag is directly proportionate to the area of the object in the fluid and the square of the velocity of the blood), 4- movement of the interatrial septum. All of these forces are minimal but continuous, eventually leading to minimal displacement of the device downwards and towards the mitral especially in pediatric population due to relatively thinner septum [19] and small area of the atria in relation to the device thickness.

In the current study, there is a significant relation to ASD size, AV rim (by 2D TTE/TEE & 3D TTE), posterior rim (by 2D TTE & 2D TEE), device size, left atrial device disc, the ratio of the left atrial device disc to the total interatrial septum length. These parameters should be taken in consideration when choosing the device size. Logistic regression analysis is done between aortic-mitral plane as a dependent variable and these parameters revealing that ASD size, AV rim size and the ratio of the left atrial device disc to the total interatrial septum length are the most significant parameters to avoid the oversizing or the encroachment on the aortico-mitral continuity plane.

This highlight the importance of AV rim, not only the postero-inferior rim length in the encroachment on the vital aortic and mitral tissues as mentioned by Mathewso et al. in 2004 [16] who presented the closure of a large ASD with deficient or absent postero-inferior rim.

As the difference in radius length between the right and left atrial discs of the Amplatzer device is 2–3 mm, both discs couldn't be hanged on both sides of the rim if it is less than 3 mm. They concluded that they can deploy stable

devices, but these devices are prone for complications, as pulmonary vein or IVC obstruction, encroachment onto the anterior mitral leaflet, or even embolization [16].

Also, Pedra et al. 2000 [17] defined a large ASD as an ASD with stretched diameter more than 26 mm. The total interatrial septum is measured in four chamber view and short axis view by TTE and/or TEE. The AV valve rim plus the average size of the ASD (measured in four chamber view and short axis view) plus the superior rim equals total interatrial septal length. Thus, a device where the left atrial disc of the Amplatzer septal occluder is equal to or smaller than the total interatrial septal length can be used [18].

Conclusion:-

3DTTE is a good modality to determine the relation of the ASD closure device to the surrounding structures before and after ASD closure. In current study, there is no residual flow across the defect or any major complication including significant mitral regurgitation, impairment of SVC, IVC or coronary sinus drainage, aortic erosion, device embolization or cardiac perforation. This study shows that ASD closure device can be deployed safely as per the device size predetermined by pre procedure 3D TTE without any major complication. Thus, it can be concluded that predetermination of ASD closure device size is possible and safe with 3D TTE.

There is significant difference in mean size of ASD but no difference in size of its surrounding rims as detected by pre procedure 3D TTE, 2D TTE and 2D TEE. So, it can also be concluded that 3D TTE is a safe and non-invasive strategy as compared to 2D TEE for deciding about suitability of device closure with sufficient rims. Based on this postulation, it may be possible to avoid 2D TEE, which is an invasive procedure and currently the method of choice for determining the suitability of device closure. This may be useful in patients in whom TEE could not be done, especially in pediatric population.

Tables

Table 1:- Demographic and baseline clinical and hemodynamic data.

TOTAL NO. OF PATIENTS	45
MEAN AGE(IN YRS)	25.4 ± 12.06
SEX	M=20 (44.4%) F=25 (55.6%)
MEAN HEIGHT(in cm)	153.8 ± 17.99
MEAN WEIGHT(in kg)	53.02 ± 15.29
MEAN BSA(in m ²)	1.49 ± 0.31
MEAN DEVICE DIAMETER(in mm)	28.53 ± 5.89 (18-40)
MEAN DEVICE DIAMETER / TOTAL SEPTAL LENGTH (by 2D TEE)	0.65 ± 0.09
MEAN LA DISC DIAMETER/ TOTAL SEPTAL LENGTH (BY 3D TTE)	0.94 ± 0.08
MEAN LA DISC DIAMETER/ TOTAL SEPTAL LENGTH (BY 2D TEE)	0.98 ± 0.09
SAFE DEPLOYMENT OF DEVICE ,ie, ASD DEVICE AWAY FROM AORTIC MITRAL CONTINUITY PLANE (BY 3D TTE POST PROCEDURE)	27
ANY RESIDUAL FLOW	NIL
ANY MAJOR COMPLICATION	NIL

Table 2:- Comparison of ASD size and its rims by 2D TTE, 2D TEE and 3D TTE.

MEAN VALUES(IN MM)	3D TTE BEFORE PROCEDURE	2D TTE BEFORE PROCEDURE	2D TEE BEFORE PROCEDURE	P value
MAX ASD SIZE	23.27 ± 4.91	20.26 ± 4.55	21.73 ± 4.99	0.013
TOTAL SEPTAL DIAMETER	45 ± 5.41	43 ± 5.56	44 ± 5.61	0.233
IVC RIM	9.95 ± 3.26	9.4 ± 3.09	10.3 ± 3.29	0.411
SVC RIM	10.97 ± 3.88	10.44 ± 4.22	11.24 ± 4.37	0.651
AORTIC RIM	5.4 ± 2.64	4.88 ± 2.91	5.2 ± 3.01	0.685
AV RIM	11.35 ± 2.97	11.71 ± 2.86	11.26 ± 3.48	0.769
POSTERIOR RIM	10.53 ± 2.76	10.62 ± 2.91	10.93 ± 2.99	0.789
SUPERIOR RIM	12.33 ± 2.53	12.33 ± 2.35	12.63 ± 2.46	0.799

Table 3:- The relation of the ASD device proximity to aortic mitral continuity plane by 3D TTE and the device/defect size ratio by 2D TEE.

ASD device/ Defect size by 2D TEE	ASD device away from aortic mitral continuity plane by 3D TTE (Safe deployment)	ASD device close to aortic mitral continuity plane by 3D TTE (Without safe deployment)	Total
< 1.5	25	16	41
>1.5	2	2	4
TOTAL	27	18	45

SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
92.59%	11.11%	60.98%	50%	60%

Table 4:- Difference in profile of cases with and without safe deployment of device.

PROFILE	WITH SAFE DEPLOYMENT (N= 27)	WITHOUT SAFE DEPLOYMENT (N=18)	P VALUE
MEAN AGE	23.7 ± 12.23	28 ± 12.01	0.251
MAX ASD (BY 2D TTE)	18.59 ± 3.7	23.33 ± 4.28	<0.001
TOTAL SEPTAL LENGTH (BY 2D TTE)	42.42 ± 5.27	44.41 ± 5.92	0.244
IVC RIM (BY 2D TTE)	9.55 ± 2.70	9.16 ± 3.66	0.683
SVC RIM (BY 2D TTE)	11.22 ± 4.85	9.27 ± 2.78	0.130
AORTIC RIM (BY 2D TTE)	5.25 ± 3.49	4.33 ± 1.68	0.305
AV RIM (BY 2D TTE)	13.11 ± 2.88	9.61 ± 0.84	<0.001
POSTERIOR RIM (BY 2D TTE)	11.57 ± 2.81	9.19 ± 2.51	0.006
SUPERIOR RIM (BY 2D TTE)	11.74 ± 2.3	12.22 ± 2.18	0.370
MAX ASD (BY 3D TTE)	21.22 ± 3.73	26.33 ± 4.95	<0.001
TOTAL SEPTAL LENGTH (BY 3D TTE)	44 ± 4.8	46.77 ± 5.96	0.092
IVC RIM (BY 3D TTE)	9.96 ± 2.45	9.94 ± 4.27	0.984
SVC RIM (BY 3D TTE)	11.55 ± 4.26	10.11 ± 3.16	0.227
AORTIC RIM (BY 3D TTE)	5.77 ± 2.97	4.83 ± 1.97	0.245

AV RIM (BY 3D TTE)	12.81 ± 3.01	9.16 ± 0.78	<0.001
POSTERIOR RIM (BY 3D TTE)	11.11 ± 2.62	9.66 ± 2.82	0.085
SUPERIOR RIM (BY 3D TTE)	11.44 ± 2.45	12.66 ± 2.05	0.130
MAX ASD (BY 2D TEE)	19.92 ± 4.09	24.61 ± 5.0	<0.001
TOTAL SEPTAL LENGTH (BY 2D TEE)	48.62 ± 5.02	43.94 ± 6.55	0.010
IVC RIM (BY 2D TEE)	10.24 ± 2.79	10.38 ± 4.01	0.891
SVC RIM (BY 2D TEE)	11.96 ± 4.91	10.16 ± 3.24	0.179
AORTIC RIM (BY 2D TEE)	5.81 ± 3.37	4.27 ± 2.13	0.093
AV RIM (BY 2D TEE)	13.29 ± 3.08	8.22 ± 0.73	<0.001
POSTERIOR RIM (BY 2D TEE)	11.7 ± 2.85	9.77 ± 2.90	0.032
SUPERIOR RIM (BY 2D TEE)	12.03 ± 2.48	12.5 ± 2.20	0.481
DEVICE DIAMETER	26 ± 4.50	32.33 ± 5.96	<0.001
LA DISC/ TOTAL SEPTAL LENGTH	0.92 ± 0.09	1.05 ± 0.03	<0.001
DEVICE/ DEFECT SIZE (BY 2D TEE)	1.31 ± 0.09	1.32 ± 0.08	0.705

Figures:-

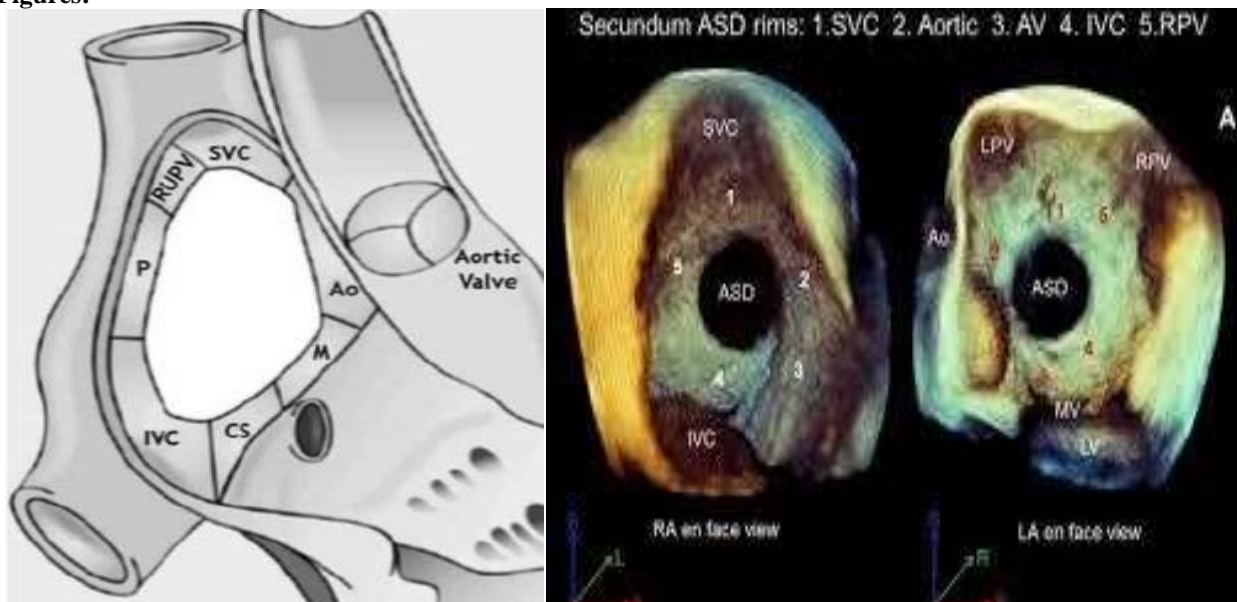


Fig 1:- A: Diagrammatic representation of ASD and its rims and its relationship with surrounding structures; B: RA and LA en face views of ASD by 3D TEE.

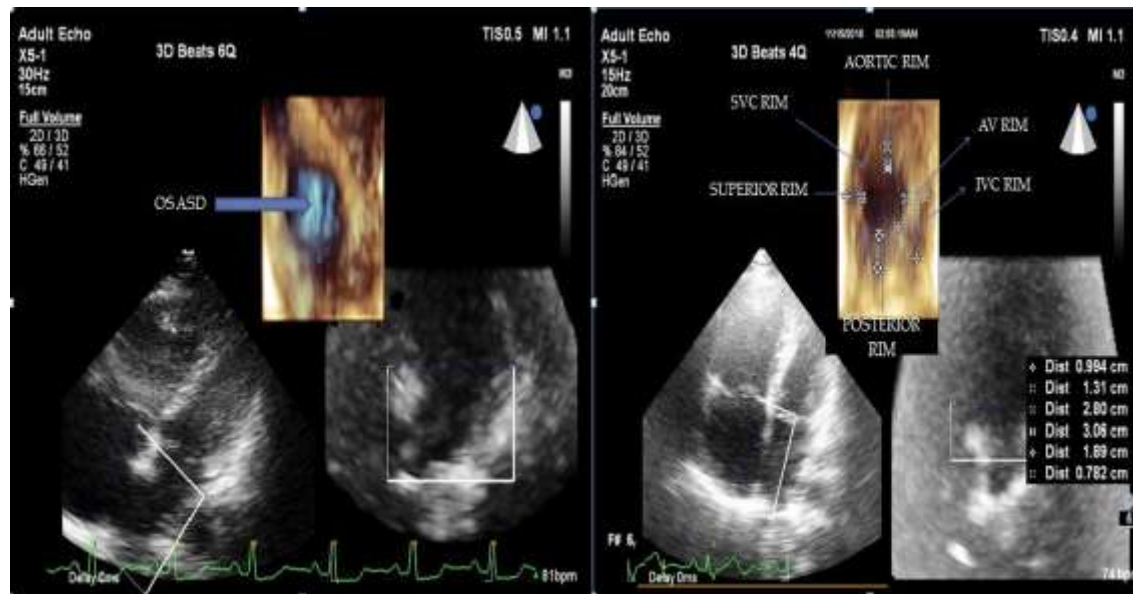


Figure 2:- RA en face views on cropping full volume 3D data acquired by Apical 4 chamber view. On left side: isolated ostium secundum ASD and its surrounding structures; on right side: OS ASD with its rims as shown by arrows.

References:-

1. Du ZD, Hijazi ZM, Kleinman CS, et al.. Comparison between trans catheter and surgical closure of secundum atrial septal defect in children and adults: results of a multicenter nonrandomized trial. J Am Coll Cardiol 2002;39:1836-44.
2. Sayamasutra Rao P. Diagnosis and management of acyanotic heart disease. Indian J Pediatr 2005;72 (6):495-502.
3. AGA: Medical Technical Note: 2006; January:1-4.
4. Wang JK, Tsai SK, Lin SM, Chiu SN, Lin MT, Wu MH. Transcatheter closure of atrial septal defect without balloon sizing. Catheter Cardiovasc Interv 2008;71 (2):214-21.
5. Amin Z, Daufors DA. Balloon sizing is not necessary for closure of secundum atrial septal defects. J Am Coll Cardiol 2005;45:317.
6. Chen CY, Lee CH, Yang MW, Chung HT, Hsieh C, Ho AC. Usefulness of transesophageal echocardiography for trans catheter closure of ostium secundum atrial septum defect with the amplatzer septal occluder. Chang Gung Med J 2005;28:837-45.
7. Aggoun Y, Gallet B, Acar P, et al.. Perforation of the aorta after percutaneous closure of an atrial septal defect with an Amplatzer prosthesis with acute severe hemolysis. Arch Mal Coeur Vaiss 2002;95(5):479-82.
8. Syamasundar Rao P. 'Atrial septal defect' book ISBN 978- 953-51-0531-2, Published: April 25, 2012.
9. Thanopoulous BD, Laskari CV, Tsoulos GS, Zarayelyan A, Vekiou A, Papadopoulos GS. Closure of atrial septal defects with the Amplatzer occlusion device: preliminary results. J Am Coll Cardiol 1998;1110-6.
10. Amin Z, Hijazi ZM, Bass JL, Cheatham JP, Hellenbrand WE, Kleinman CS. Erosion of Amplatzer septal occluder device after closure of secundum atrial septal defect: review of registry of complications and recommendations to minimize future risk. Catheter Cardiovasc Interv 2004;63 (4):491-502.
11. Hellenbrand WE, Fahey JT, McGowen FX, Weltin GG, Kleinman CS. Transesophageal echocardiographic guidance of trans catheter closure of atrial septal defect. Am J Cardiol 1990;1(66):207-13.
12. Godart F, Rey C, Francart C, Jarrar M, Vaksmann G. Two dimensional echocardiographic and color Doppler measurements of atrial septal defect, and comparison with the balloon-stretched diameter. Am J Cardiol 1993;72:1095.
13. Moore J, Hegde S, Howida El-Said, Beekam R, Lee B, Bergersen L, et al..
14. Transcatheter device closure of atrial septal defects: a safety review. J Am Coll Cardiol Interv 2013;6(5):433-42.
15. Song J, Lee SY, SookBaek J, Shim WS, Choi EY. Outcome of trans catheter closure of oval shaped atrial septal defect with Amplatzer septal occluder. Yonsei Med J 2013;54 (5):1104-9.
16. Watanabe N, Tniguchi M, Akagi T, Toh N, Kusano K, Ito H, et al.. J Am Soc Echocardiogr 2012;25(4):376-82.

17. Mathewson JW, Bichell D, Rothman A, Ing FF. Absent posteroinferior and anterosuperior atrial septal defect rims: Factors affecting nonsurgical closure of large secundum defects using the Amplatzer occluder. *J Am Soc Echocardiogr*;2004; Vol. 17, No. 1, pp. 62–69.
18. Mathewson JW, Bichell D, Rothman A, Ing FF. Absent posteroinferior and anterosuperior atrial septal defect rims: factors affecting nonsurgical closure of large secundum defects using the Amplatzer occluder. *J Am Soc Echocardiogr* 2004;17(1):62–9.
19. Hijazi ZM, Cao Q-L. Transcatheter closure of multifenestrated atrial septal defects using the new Amplatzer cribriform device. *Congenital Cardiol Today* 2010;1:1–4.
20. El Saiedi SA, Attia WA. New pediatric version of balloonassisted technique for atrial septal closure using selfcentering devices: relation to interatrial septal thickness. *J Invasive Cardiol* 2015;27(11):510–5.