Value of 3D echocardiography in diagnosis of complex congenital heart disease patients before and after surgical intervention

Mohamed Hesham Hassan Ezzat[1], Kamal Ahmed Marghany[1], Hassan El-Sawy[2] and Nasser Mahmoud El-Serafy[3]

[1]Cardiology Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt.
[2]Pediatric Surgery Department, National Heart Institute, Cairo, Egypt.
[3] Cardiology Department, National Heart Institute, Cairo, Egypt.
nasserserafy@gmail.com

Abstract: Background: Three dimensional echocardiography imaging represents a major innovation in cardiovascular ultrasound. Advancements in computer and transducer technologies permit real time 3D echocardiography acquisition and presentation of cardiac structures from any spatial point of view. Treatment of congenital heart defects, whether by surgical or intervention means, demands an understanding of the cardiac lesions to plan the optimal approach. The use of live 3D echocardiography in congenital heart disease was discussed in several studies with documented role in assessment of septal defects, valvular lesions. However, its use in complex congenital malformations had been tested in few studies without the elaboration of a protocol or a specific technique to study such complex malformation.

[Mohamed Hesham Hassan Ezzat, Kamal Ahmed Marghany, Hassan El-Sawy and Nasser Mahmoud El-Serafy. **Value of 3D echocardiography in diagnosis of complex congenital heart disease patients before and after surgical intervention.** *Nat Sci* 2017;15(3):67-75]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 9. doi:10.7537/marsnsj150317.09.

Key words:3D echocardiography, congenital heart disease, 2D echocardiography, surgical intervention.

1. Objectives:

Is 3D echocardiography is better than 2D echocardiography in diagnosis of complex congenital heart disease patients?

2. Patient and method

The study comprised 28 patients with complex congenital heart disease scheduled for echocardiography in Cardiology Department of AL-Hussein University Hospital and National Heart Institute, between December 2014 and August 2016. With exclusion of patients who had cardiac surgery before, patients unfit for surgery or patients refuse the surgery.

All patients were subjected to the following:

History taking and clinical examination.

Routine investigations: Chest X-ray,12 lead ECG, CBC, coagulation profile and arterial oxygen saturation was measured.

Two-dimensional echocardiography

Three-dimensional echocardiography; after completing the 2D echocardiography, all the cases were subjected to 3D echocardiography.

-Their value will be evaluated by analysis using a5-points categorical scale in major cardiovascular structure and spatial relationships among complex CHD which is: 1- Definitely Correct showing that, all echocardiographic diagnoses were confirmed with surgical findings. 2-Correct, showing those main echocardiographic diagnoses were confirmed with surgical findings. 3- Partially correct showing that partial echocardiographic diagnoses were not confirmed with surgical findings. 4-Wrong showing that main echocardiographic diagnoses were not confirmed with surgical findings. 5-Definitely wrong all echocardiographic diagnoses were not confirmed with surgical findings **(Chen, *et al*. 2008).**

- All studies were individually reviewed and reconstructed offline by two cardiologist's expert in echocardiography of congenital heart disease. The technical quality of the 3D echocardiographic acquisitions was classified as ‘‘excellent’’ (well-defined borders with minimal dropout as well as transparent chamber and vessel lumens), ‘‘satisfactory’’ (less border definition, with areas of dropout and haze in the chamber and vessel lumens that did not obscure underlying structures), or ‘‘poor’’(uneven image density with poor border definition and extensive dropout, or densities within the chamber and vessel lumens that obscured underlying structures). The technical quality of the acquired 3D images was defined separately by the two cardiologists. Images were classified as ‘‘excellent’’ if both expert cardiologists judged them to be excellent or ‘‘satisfactory’’ if at least one cardiologist judged them to be satisfactory. The two expert cardiologists then reviewed all the 3D acquisitions separately, classifying them as ‘‘very useful’’ if new anatomic information was added to the 2D echocardiography report or a specimen-like demonstration of the anatomy was accomplished, ‘‘useful’’ if only a clearer 3D anatomic definition was obtained (useful for learning and teaching anatomy but without additional diagnostic benefit), and ‘‘not useful’’ if nothing was added to the 2D echocardiographic data. The 3D studies were classified as‘‘very useful’’ if both cardiologists judged them to be ‘‘very useful,’’ and ‘‘useful’’ if at least one judged them to be useful **(Pasqua, *et al*. 2009).**

-We will compare VSD, ASD size and number, degree of overriding of aorta in TOF (tetralogy of fallot), DORF (Double outlet right ventricle) and truncus and size of aortic root in all Cases.

-We will compare size of all pulmonary parameter in TOF patients.

-We will compare the accuracy of 2D and 3D in finding coronary arteries.

-2D and 3D after intervention if possible.

Surgical procedure:

Both the 2D and the reconstructed 3D images were reviewed by cardiologists and surgeons before the surgical correction of the defects, and the echocardiographic findings were compared with the surgical observations. The surgeons then compared the impression of the surgical anatomy gained by review of the 3D and 2D images with the actual anatomy observed at surgery and measure the cardiac defects (VSD and ASD) in maximum and minimum diameter and measure aortic root diameter, aortic overriding,all pulmonary artery (PA) parameter proximal and distal (main PA,right and left PA).All cases had corrected surgically.

Statistical Analysis:

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 20. The qualitative data were presented as number and percentages while quantitative data were presented as mean,standard deviations and ranges when their distribution found parametric and were presented as median with inter quartile ranges (IQR) when their distribution found non-parametric.

3. Results

The study comprised 28 patients with complex congenital heart disease scheduled for echocardiography in Cardiology Department of AL-Hussein University Hospital and National Heart Institute, between December 2014 and August 2016. The studied population included 18 males (64.3%) and 10 females (35.7%), with a Median (IQR = international quantitative ratio) age of 2 (2 - 14) years (range 6 months to 28 years). Diagnosis of our patients include 12 patients (42.9%) diagnosed as tetralogy of Fallot (TOF), 2 patients (7.1%) as Ebstein with ASD (atrial septal defect), 2 patients (7.1%) as DORV (Double outlet right ventricle) with VSD (ventricular septal defect), 2 patient as D-TGA (Dextro-Transposition of great arteries) (7.1%),2 patient as L-TGA (Levo-) (7.1%), 3 cases as truncus (10.7), 1 case as TAPVD (Total anomalous pulmonary venous driange), 2 patient as TA (Tricuspid atresia) and 2 patient as DiLV (Double inlet left ventricle) (7.1%).

Table 1: Patient characteristics

		Total number = 28 pts
Age	Median (IQR)	2 (2 - 14)
	Range	0.6 - 28
Wt	Median (IQR)	10.5 (9 - 32.5)
	Range	5 - 80
Sex	Female	10 (35.7%)
	Male	18 (64.3%)
Diagnosis	DILV	2 (7.1%)
	DORV	2 (7.1%)
	DTGA	2 (7.1%)
	Ebstein	2 (7.1%)
	LTGA	2 (7.1%)
	TA	2 (7.1%)
	TAPVD	1 (3.6%)
	TOF	12 (42.9%)
	Truncus	3 (10.7%)
X-ray	LVH	4 (14.3%)
	RVH	13 (46.4%)
	UR	11 (39.3%)

LVH = left ventricular hypertrophy, RVH = right ventricular hypertrophy, RVH,UR = unremarkable

The 2D was done for each patient as a commonly used standard for segmental sequential analysis of complex congenital cardiac malformations. 2D echocardiography was used as the cornerstone investigation in the present study.

Table 2: Data of each patient diagnosed by 2D echocardiography.

Serial	Apex	Situs	AV connection	VA connection	Aortic arch	Diagnosis
Case1	L	S	C	C	L	TOF, Pulmonary atresia
Case2	L	S	C	C	L	TOF
Case3	L	S	C	C	L	TOF
Case4	L	S	C	C	L	TOF
Case5	L	S	C	C	L	TOF
Case6	L	S	Uni (TA)	C	L	Tricuspid atresia, VSD, ASD, PDA,PS and dilated LV.
Case7	L	S	DILV	C	L	Duoble inlet LV +PS.
Case8	L	S	Uni(TA)	C	L	Tricuspid atresia common inlet LV,ASD, VSD and PS.
Case9	L	S	C	Single trunk	L	Truncus type 1 with long tortuous dilated MPA and large subtruncal VSD.
Case10	L	S	C	C	L	TOF
Case11	L	S	C	DORV	L	DORV+Complete AVSD+PS
Case12	L	S	C	C	L	TOF+ASD
Case13	D	I	C	C	L	TOF+ASD+PVO
Case14	L	S	C	C	L	TOF +ASD
Case15	L	S	C	Single Trunk	L	Truncus type 1
Case16	L	S	C	D	L	DTG A+VSD+PS
Case17	L	S	C	DORV	L	DoRV subaortic VSD/ sever PS
Case18	L	S	C	C	L	TOF, ASD and pulmonary atresia
Case19	L	S	D	D	L	L-TGA sever TR inlet VSD +valvular PS
Case20	L	S	C	C	L	TAPVD supracardiac type
Case21	L	S	C	C	L	TOF+PDA
Case22	L	S	C	Single trunk	L	Truncus type 11 persistent LSVC
Case23	L	S	C	C	L	Ebsteins anomaly+ASD
Case24	L	S	C	D	L	DTG A + ASD +PS.
Case25	L	S	D	D	L	L-TGA, sever TR, inlet VSD and valvular PS.
Case26	L	S	C	C	L	TOF
Case27	L	S	DILV	C	L	Duoble inlet LV,PS and malposed great vessels
Case28	L	S	C	C	L	Ebsteins anomaly+ASD

D = discordance, C = concordance, L = left, S = situs, PS = pulmonary stenosis, AVSD = atrioventricular septal defect, L = left, ASD = atrial septal defect, VSD = ventricular septal defect, PFO = patent foramen ovale, LSVC = left superior vena cavae, DORV = Double outlet right ventricle, D-TGA = Dextro-Transposition of great arteries, L-TGA = Levo - Transposition of great arteries, TAPVD = Total anomalous pulmonary venous driange, TA = Tricuspid atresia, DiLV = Double inlet left ventricle, PA = pulmonary artery, MPA = main pulmonary artery, TR = tricuspid regurge, PDA = patent ductus artriosus, TOF = tetralogy of Fallot.

The 3D images were graded as excellent (E) by the two cardiologists for 61% (17/28), satisfactory (S) for 39% (11/28) of the patients. The 3D images were judged very useful for 25% (7/28), useful for 46.4% (13/28) and not useful for 28.6% (8/28) of the patients.Three-dimensional echocardiography was very useful for 8.3% (1 in 12 cases) of TOF,100% (2 in 2 cases) of the Ebstein anomalies, 33% (1 in 3 cases) of the truncus, 50% (2 in 4 cases) of the transpositions of the great arteries with a ventricular septal defect, and 50% (1 in 2 cases) of the double-outlet right ventricles. Three-dimensional echocardiography established the decision of intervention by replacement or repair of TV in the two cases (23, 28) which the 2D can not see the three leaflet of Ebstien patient, as the two patients were adult. In addition, it clarified the diagnosis, which was unclear from the 2D echocardiogram, for one patient affected by anomalous of RCA and inform the surgeon to take care during incision not to injury the RCA (case 18). There was no difference in image quality or anatomic information between the 3D studies reconstructed by the two cardiologists.

Table 3: Statistical analysis of 2D data.

2D measurements		**Number of patients = 28**
VSD number in each patient = 1		Number of patients who have VSD = 20 (71.40%)
VSD size	Mean±SD	10.03 ± 3.69
	Range	5 – 19
ASD number in each patient = 1		Number of patients who have ASD = 9 (32.10%)
ASD size	Mean±SD	9.22 ± 4.50
	Range	2 – 19
Overriding of aorta	Mean±SD	46.47 ± 11.56
	Range	35 – 75
Aortic root	Mean±SD	1.92 ± 0.61
	Range	1.3 – 3.5
Main PA proximal	Mean±SD	0.91 ± 0.37
	Range	0.3 – 1.4
Main PA distal	Mean±SD	0.94 ± 0.30
	Range	0.5 – 1.4
Rt. PA proximal	Mean±SD	0.90 ± 0.40
	Range	0.3 – 1.8
Rt. PA distal	Mean±SD	1.05 ± 0.32
	Range	0.7 – 1.8
Lt. PA proximal	Mean±SD	0.69 ± 0.24
	Range	0.4 – 1.2
Lt. PA distal	Mean±SD	0.98 ± 0.42
	Range	0.5 – 1.8
Coronary detection Rt.	Not seen in 7 patients	7 (25.0%)
	Seen in 21 patients	21 (75.0%)
Coronary detection Lt.	Not seen in 5 patients	5 (17.9%)
	Seen in 23 patients	23 (82.1%)
2D results	Correct in 11 patients	11 (39.3%)
	Definitely correct in 17 patients	17 (60.7%)

Table 4: Useful and not useful as regarding to 3D and 2D.

Case n.	Wt. (kg)	Age (years)	Type of CCHDs	ACQ	Results
(1)	10	2	TOF. + Pulmonary atresia.	E	U
2))	60	25	TOF (tetralogy of Fallot).	E	U
3))	12	3	TOF.	E	U
4))	35	15	TOF.	S	U
5))	11	2	TOF.	S	NU
(6)	10	2	Tricuspid atresia, VSD, ASD, PDA, PS and dilated LV.	E	NU
(7)	62	23	Double inlet LV +PS.	E	U
(8)	9	2	Tricuspid atresia common inlet LV, ASD, VSD and PS.	E	U
(9 (	6	0.8	Truncus type 1 with long tortuous dilated MPA and large subtruncal VSD.	E	NU
(10)	25	10	TOF	E	UN
(11)	11	2,5	DORV, complete AVSD and PS.	E	UN
(12)	9	2	TOF and ASD.	S	NU
(13)	8	2	TOF, ASD and PFO	S	U
(14)	10	2	TOF and ASD.	S	U
(15)	5.5	0.7	Truncus type 1.	S	U
20))	9	2	TAPVD Supra cardiac type.	S	U
(21)	10	2	TOF and PDA.	S	NU
(24)	10	2	DTG A + ASD +PS.	E	U
(25)	11	2	L-TGA, sever TR, inlet VSD and valvular PS.	S	U
(26)	15	*5*	TOF	S	NU
(27)	45	*20*	Double inlet LV, PS and malposed great vessels.	S	U

U = useful, NU = not useful, ACQ = acquisition, n = number, wt. = weight, CCHD = complex congenital heart disease, S = satisfactory, kg = kilogram, PS = pulmonary stenosis, AVSD = atrioventricular septal defect, L = left, ASD = atrial septal defect, VSD = ventricular septal defect, PFO = patent foramen ovale, LSVC = left superior vena cavae, DORV = Double outlet right ventricle, D-TGA = Dextro-Transposition of great arteries, L-TGA = Levo - Transposition of great arteries, TAPVD = Total anomalous pulmonary venous driange, TA = Tricuspid atresia, DiLV = Double inlet left ventricle, PA = pulmonary artery, MPA = main pulmonary artery, TR = tricuspid regurge, PDA = patent ductus artriosus, LV = left ventricle, TOF = tetralogy of Fallot.

Table 5: Very useful studies as regarding to 3D and 2D.

Case (n)	Wt. (Kg)	Age (year)	Type of CCHDs	ACQ	3D value
(16)	30	13	DTGA +VSD+PS	E	Direct visualization of VSD It's interrelation with aortic and pulmonary valves.
17))	9	2	DoRV subaortic VSD/ sever PS	E	View demonstrating the sub aortic VSD and the distance of the the aorta from LV (Very useful to surgeon for VSD closure and creation of the Tunnel LV – aorta).
)18)	10	2	TOF, ASD and pulmonary atresia	E	Anomalous course of RCA on RVOT and left subclavian A shows proximal stenosis.
(19)	35	15	L-TGA sever TR inlet VSD +valvular PS.	E	Demonstration of the interrelations between the great arteries, ventricles, and VSD with the en faces view of the AV valves.
22))	5	0.6	Truncus type 11 persistent LSVC	E	Direct demonstration of separate origin of 2 pulmonary branches.
(23)	80	28	Ebsteins anomaly+ASD	E	Clear and detailed visualization of anterior leaflet of TV. and its relation to septum which found that free leading edge and 70% delamination of the anterior tricuspid leaflet.
(28)	70	25	Ebsteins anomaly+ASD	E	Clear and detailed visualization of anterior leaflet of TV. and its relation to septum which found that leading edge is not free and 40% delamination of the anterior tricuspid leaflet.

E = Excellent, n = number, ACQ = acquisition**,** wt. = weight, CCHD = complex congenital heart disease, ASD = atrial septal defect, PS = pulmonary stenosis, TR = tricuspid regurge, DORV = Double outlet right ventricle, D-TGA = Dextro-Transposition of great arteries, L-TGA = Levo - Transposition of great arteries. Tetralogy of Fallot (TOF), VSD = ventricular septal defect, LSVC = left superior vena cavae.

Table 6: Statistical analysis of 3D data.

3D parameters		
VSD		
Size in LV enface		
End diastolic		
Maximum	Mean±SD Range	13.21 ±3.44 6.7 – 21
Minimum	Mean±SD Range	8.11 ± 4.01 3.7 – 18
End systolic		
Maximum	Mean±SD Range	11.57 ± 3.29 5.2 – 16.5
Minimum	Mean±SD Range	7.69 ± 3.34 2.4 – 15
Size in RV enface		
End diastolic		
Maximum	Mean±SD Range	12.68 ± 3.61 7.5 – 20
Minimum	Mean±SD Range	9.02 ± 3.87 5.3 – 18.5
End systolic		
Maximum	Mean±SD Range	11.01 ± 3.47 6 – 18
Minimum	Mean±SD Range	8.05 ± 3.85 3 – 17
VSD number = 20	Number of patients who have one VSD = 19 Number of patients who have twoVSD = 1	19 (67.86%) 1 (3.57%)
ASD number = 9	Number of patients who have one ASD = 8 Number of patients who have two ASD = 1	8 (28.57%) 1 (3.57%)
ASD size	Mean±SD Range	10.24 ± 5.55 2 – 23
Overriding of aorta	Mean±SD Range	48.12 ± 9.11 40 – 70
Pulmonary		
Main PA proximal	Mean±SD Range	1.04 ± 0.41 0.4 – 1.6
Main PA Distal	Mean±SD Range	1.07 ± 0.36 0.5 – 1.6
RT. PA Proximal	Mean±SD Range	1.05 ± 0.41 0.4 – 1.9
RT. PA Distal	Mean±SD Range	1.20 ± 0.32 0.8 – 1.9
LT. PA Proximal	Mean±SD Range	0.80 ± 0.24 0.4 – 1.3
LT. PA Distal	Mean±SD	1.13 ± 0.41
Aortic root	Mean±SD Range	1.95 ± 0.61 1.3 – 3.5
Coronary detection RT.	Not seen in 3 patients Seen in 25 patients	3 (10.7%) 25 (89.3%)
Coronary detection LT.	Not seen in 2 patients Seen in 26 patients	2 (7.1%) 26 (92.9%)
3D results	Correct in 3 patients Definitely correct in 25 patients.	3 (10.7%) 25 (89.3%)

In about one-quarter of our studies, the 3D echocardiogram added new anatomic details, and in some selected cases, established the correct diagnosis, which was missed or only suspected by 2D echocardiography. All parameters of our study (VSD, ASD, pulmonary artery and branches, aortic root overriding of aorta and coronary arteries finding) shows that there are excellent correlation between 2D, 3D and surgery but 3D is more significant.

After the surgical repair, the surgeon indicated a detailed correspondence of the 2D and 3D images to the surgical findings in all cases.

Table 7: Statistical analysis of surgical data.

Surgery		
VSD number	Number of patients who have one VSD = 19 Number of patients who have two VSD = 1	19 (67.86%) 1 (3.57%)
VSD Size maximum	Mean±SD Range	14.58 ± 3.50 10 – 21
VSD Size minimum	Mean±SD Range	10.62 ± 3.35 7 – 19
ASD Size	Mean±SD Range	10.36 ± 5.53 2 – 23
ASD number	Number of patients who have one ASD = 8 Number of patients who have two ASD = 1	8 (28.57%) 1 (3.57%)
Overriding of aorta	Mean±SD Range	48.44 ± 9.78 40 – 70
Aortic root	Mean±SD Range	1.95 ± 0.61 1.3 – 3.5
Pulmonary		
Main PA Proximal	Mean±SD Range	1.05 ± 0.42 0.4 – 1.6
Main PA Distal	Mean±SD Range	1.08 ± 0.36 0.5 – 1.6
RT. PA Proximal	Mean±SD Range	1.06 ± 0.40 0.4 – 1.9
RT. PA Distal	Mean±SD Range	1.20 ± 0.32 0.8 – 1.9
LT. PA Proximal	Mean±SD Range	0.81 ± 0.25 0.4 – 1.3
LT. PA Distal	Mean±SD Range	1.13 ± 0.41 0.7– 2

4. Discussion

In our study, we found groups of complex congenital heart defects.

• Valvular abnormalities:

In Ebstein's anomaly (cases 23,28) it was easier to understand the anatomy of the anterior leaflet, which typically is difficult to visualize with 2D echocardiography. Because subcostal views were needed to display the anterior leaflet, this approach is applicable only for infants and small children **(Bleich, *et al.*, 2013).** 3D change planning and permitted a realistic preview of the anatomy, which surgeons found particularly helpful for planning surgery. in (cases 23,28), the degree of tethering of tricuspid valve (TV) leaflets and free leading edge and percentage of delamination of the anterior tricuspid leaflet make decision valve replacement or repair, so thanks to 3D. Many studies are agree with us **Zhang *et al.*, 2012** studied the use of 3D TTE in patients with Ebstein's anomaly and found this imaging to be valuable in the identification of the distribution and extent of tethering of individual of tricuspid valve leaflets. **John *et al.*, 2011** stated that 3DE provide a depth of field that cannot be achieved by 2DE and novel projections of anatomy of the valves can be produced both from the ventricular side or the atrial side (surgical view).

Shunt lesions (VSD, ASD and AVSD):

-VSD

3D echocardiograms also were very powerful for demonstrating the position and orientation of ventricular septal defects with respect to the outflow tracts in the double-outlet right ventricle (cases 17 and 11) and in transposition of the great arteries with bilateral conus (case 16). The direct 3D visualization of the potential tunnel from the left ventricle to the aorta in patients undergoing REV or Rastelli-type operations permitted a realistic preview of the anatomy, which surgeons found particularly helpful for planning surgery. All the cases with VSDs in the study were adequately visualized using 2D except one case where 2D found single VSD but 3D and surgery found 2 VSD. 3D echocardiography was superior in identifying the the size of VSD especially in end diastolic of LV en face, shape of the defect as well as its spatial relationship. From the en face view the VSD could be visualized from both the right and left ventricular sides offering unique anatomical details especially its relationship to the outflow tracts and AV valves which can have a great impact on surgical procedures. The additive effects of 3D echocardiography in cases with VSD were addressed by **Mehmood, *et al.*, 2004**, **Seliem *et al*., 2006** and **Simpson & Miller, 2011** and others.

-ASD In our study all the atrial septal defects were visualized by 2D except one case where 2D found single ASD but 3D and surgery found 2 ASD. The en face views of the inter-atrial septum derived from live scanning were better than those derived from the cropped sub costal full volume due to the occasional presence of a stitch artifact in the middle of the septum. The en face view showed the shape of the ASD and the relation to adjacent structures as they exist in reality and we found 3D is highly significant (r=0.996**) but 2D is significant (r = 0.719*) as regarding ASD size. Many study were agree with us in study done **by Simpson & Miller, 2011** they found that many of advantages of 3D echocardiographic assessment of atrial septal defects defects as size, number, shape and precise location of the atrial septal defect can be visualized either as a guide to surgical planning or to guide catheter intervention for defects thought suitable for catheter closure.

• Complex congenital heart defects with unusual spatial relationships:

For very complex heart defects such as anatomically corrected malposition of the great arteries (case 27), the full-volume 3D echocardiograms permitted a ‘‘specimen-like’’ display of the anatomy that greatly facilitated making an accurate diagnosis. These complex diagnoses can be very difficult to make using conventional 2D echocardiography, even by experienced cardiologists. Many studies agree with us. **Enar, *et al*., 2009 and Bleich, *et al*. 2013** found that 3D TTE have been consistent with data obtained intra operatively confirming its accurate description. This information gives cardiologists a more confident sense of the size, shape, and morphology of the defect and can assist in appropriate pre surgical preparation and eventual repair. Intra atrial baffle obstructions occur in as many as 40% of patients undergoing the Mustard procedure making its identification crucial.

• Coronary anatomy: Using 3D echocardiography, the left main coronary artery was visualized in 92.9% of the cases (26/28 cases) and the right coronary artery was visualized in 89.3% of the cases (25/28 cases). One case had an abnormal RCA anatomy. Using 2D echocardiography, the left main coronary artery was visualized in 82.1% of the cases (23/28 cases) and the right coronary artery was visualized in 75% of the cases (21/28 cases). 3D echocardiogram in case 18 clarified the final diagnosis, which was suspected but not well demonstrated by the 2D echocardiogram. Case 18. Had anomalous anatomy of RCA which runs in interatrial septum. 3D change planning and permitted a realistic preview of the anatomy, which surgeons found particularly helpful for planning surgery and no injury was done during incision. Also **Bleich, *et al*. 2013** found that 3D TTE may be able to visualize anomalous coronary arteries missed by 2D TTE and **Tworetzky *et al*. 1999** have shown that 2D is poor tool in diagnosis coronary artery anatomy, and the majority of a large group of patients with major congenital heart defects can undergo primary complete repair safely after echocardiography alone as the definitive preoperative diagnostic modality. But **Lourdes *et al*., in 2013,** had stated that coronary anatomy could be visualized by 2D echocardiography very clearly with comparable results like that seen in cardiac catheterization, that’s why most of big centers are now depending on echocardiography as a fundamental tool for preoperative evaluation of patients with tetralogy of Fallot.

•Assessment of the ventriculoarterial junction: The VA connection was determined using a combination of cuts by cropping and rotation in different planes. The present study contained 4 modes of VA connection which were correctly identified in 28 cases using 2D and 3D echo. **Lin and colleagues, 2004** found that both 2D and 3D echocardiography confirmed the VA connection in 100% of their cases. But In the study by **Chen and colleagues, 2003,** 3D echocardiography corrected the diagnosis made by 2D echocardiography of a DORV case into transposition of great vessels which was later surgically validated **(Chen *et al*, 2003).**

• Assessment of the Mc Goons index: In our study there is excellent correlation between 2D, 3D and surgery but 3D is more significant, our results were comparable to **Seliem and colleagues 2006**, they found excellent correlation between 2D and 3D but 3D is superior.

• Accuracy of 2D and 3D results in prediction of surgery as the gold standard tools: In our study there were 89.3% of the definitely correct in 3DE and

64% in 2DE. There was significant difference between them by the method of Z test (Z= 0.039). The accuracy of 3D is higher than 2D as Definitely correct of 3D is higher than 2D and we found only Definitely correct and correct. Our study was in accordance with the study carried by **Chen**, ***et al*****. 2008** who study thirty patients with complex CHD by 2-dimensional echocardiography (2DE) and RT3DE. Their value was evaluated by ROC analysis using a5-point categorical scale in major cardiovascular structures and spatial relationships among complex CHD and Compared with surgical findings, there were 75.6% of the definitely correct in 3D and 64.4% in 2DE. There was significant difference between them by the method of Z test (Z = 2.64, P = 0.0083). But our study was discordance in that he found that among studded cases there were partially correct, and wrong.

Conclusion

Our study shows that routine use of 3D echocardiography is feasible and particularly useful for complex heart defects in which an understanding of the relationships between structures is necessary for good surgical planning. The combination of 2D and 3D imaging increases the diagnostic sensitivity of echocardiography. In about one-quarter of our studies, the 3D echocardiogram added new anatomic details, and in some selected cases, established the correct diagnosis, which was missed or only suspected by 2D echocardiography. This technology provides the surgeon with a realistic anatomic preview of the anatomy and is a very useful guide for surgical planning. Finally, 3D echocardiography is a powerful means for teaching students.

Recommendation

Real-time 3D echocardiography is recommended when available with 2D for all Patients with complex congenital heart disease before surgical intervention.

References

1. Ahmed S, Nanda NC, Nekkanti R. (2003): Transesophageal three-dimensional echocardiographic demonstration of Ebstein's anomaly. Echocardiography; 20:305–306.
2. Ahmed S, Nekkanti R, Nanda NC. (2003): Three-dimensional transesophageal echocardiographic demonstration of intraatrial baffle obstruction. Echocardiography; 20:683–686.
3. Alessia Del Pasqua, Stephen P. Sanders, Andrea de Zorzi. (2009): Impact of Three-Dimensional Echocardiography in Complex Congenital Heart Defect Cases: The Surgical View, Pediatr Cardiol, 30:293–300.
4. Chen GZ, Sun K, Chen SB, Zhang YQ, Jiang H. (2003): Transthoracic three dimensional echocardiographic diagnosis of double outlet right ventricle [in Chinese]. Chin J Ultrasound Med; 19:821-4.
5. Chen GZ, Huang GY, Tao ZY.(2008): Value of real-time 3-dimensional echocardiography sectional diagnosis in complex congenital heart disease evaluated by receiver operating characteristic analysis. J Am Soc Echocardiogr;21:458–463.
6. Enar S, Singh P, Douglas C. (2009): Live/real time three dimensional transthoracic echocardiographic assessment of transposition of the great arteries in the adult. Echocardiography; 26:1095–1104.
7. John M. Simpson and Owen M. (2011): 3DE in congenital heart disease Archives of cardiovascular Disease; 104: 45-56.
8. Lin CC, Hsieh KS, Huang TC. (2004): Evaluation of complex congenital heart diseases with Real-Time Three - dimensional echocardiography. Acta Cardiol Sin; 20:21-30.
9. Lourdes R, Marcy L, Richard S, Janine A and Tamar J. (2013): Preoperative diagnostic evaluation. In: Anderson R, ed. Pediatric cardiac surgery. United Kingdom: Wiley-Blackwel: 60-84.
10. Mehmood F, Vengala S, Nanda NC. (2004): Usefulness of live three-dimensional transthoracic echocardiography in the characterization of atrial septal defects in adults. Echocardiography; 21:707—13.
11. Mehmood F, Miller AP, Nanda NC. (2006): Usefulness of live/real time three-dimensional transthoracic echocardiography in the characterization of ventricular septal defects in adults. Echocardiography; 23:421–427.
12. Wayne Tworetzky. (1999): Echocardiographic Diagnosis Alone for the Complete Repair of Major Congenital Heart Defects (J Am Coll Cardiol; 33:228 –33).
13. Seliem MA, Fedec A, Cohen MS, Ewing S, Farrell Jr PE, Rychik J. (2006): Real-time 3-dimensional echocardiographic imaging of congenital heart disease using matrix array technology: freehand real-time scanning adds instant morphologic details not well delineated by conventional 2-dimensional imaging. J Am Soc Echocardiogr;19 (2):121–9.
14. Steven Bleich, M.D., Navin C. Nanda, M.D. and Fadi G. Hage, M.D (2013): The Incremental Value of Three-Dimensional Transthoracic Echocardiography in Adult Congenital Heart Disease. Echocardiography;30:483-494.
15. Zhang L, Xie MX, Balluz R.(2012): Real-time 3-dimensional echocardiography for evaluation of congenital heart defects: State of the art. Echocardiography;29:232–241.

2/10/2017