Impact of Accuracy of Preoperative Transthoracic Echocardiography on Complex Congenital Heart Surgery in Pediatrics

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ABSTRACT

Objective: In simple congenital heart disease, transthoracic echocardiography for the diagnosis and preoperative evaluation is an effective investigation. But its role in complex congenital heart disease is yet to be proven. The aim of this study was to find an accuracy ratio of preoperative echocardiography in complex congenital heart disease and the effect of non-equivalent findings to surgical plan and outcomes.

Methods: Medical records of complex congenital heart disease patients who underwent open heart surgery during 2013 -2015, including echocardiographic reports, operative notes, in-patient and out-patient data were retrospectively reviewed. Patients who underwent palliative shunt procedure, age > 15 year and missing data were excluded. A total of 300 patients were included in the study. We used intraoperative findings as a gold standard to compare with preoperative transthoracic echocardiography. Then, we analyzed data comparing between groups of patients who had concordant and non-concordant echocardiographic finding. After that we compared between groups of patients who had surgery changed from the preoperative plan and those who had not. SPSS version 18 was used to analyze.

Results: The concordance of preoperative echocardiography was 77.7%. In the non-concordant data group, approximately one third had to change the plan of operation and about one tenth had to change cannulation technique. Most of non-concordance were that of systemic venous drainage and coronary artery pattern. But it had no significant effect to surgical outcomes including operative time, cardiopulmonary bypass time, morbidity and mortality rate.

Conclusion: Transthoracic echocardiography is valuable tool that give a lot of details on anatomical and physiological data in congenital heart disease. However, some complex congenital heart patients may need additional investigations such as cardiac catheterization, CT scan, Cardiac MRI in order to obtain adequate anatomical and physiological data for surgical planning.

Keywords: Preoperative; transthoracic echocardiography; complex congenital heart surgery (Siriraj Med J 2019; 71: 480-485)

INTRODUCTION

In congenital heart surgery, anatomical and physiological data are important in planning the surgical procedure. In the past, cardiac catheterization was used to obtain the information. However, cardiac catheterization is an invasive procedure with some procedural risks. Nowadays, echocardiography as an imaging modality has improved tremendously. We can obtain many anatomical and physiological data from this non-invasive procedure. In simple congenital heart diseases such as atrial septal

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defect (ASD), ventricular septal defect (VSD) and patent ductus arteriosus (PDA), we can do surgery based solely on preoperative echocardiography.[1-6] During recent years, there has been many studies suggested that we can also perform complex congenital heart surgery based on preoperative echocardiographic finding alone without increasing the risk of the complication and overall outcome.[7-13] However, this had to be proven and is still not a standard practice in our institute. We usually have both preoperative echocardiography and cardiac catheterization in complex congenital heart patients.

The aim of this study is to find out the proportion of complex congenital heart patients with concordant data between preoperative echocardiogram and surgical findings and its impact on surgical plan and outcomes.

Complex congenital heart disease in this study includes all congenital heart disease except atrial septal defect (ASD), ventricular septal defect (VSD) and patent ductus arteriosus (PDA).

Objectives

Primary Objective

1. To assess the proportion of patients with concordant data between preoperative echocardiography and intra-operative findings.

Secondary Objectives

2. To study the impact of non-concordance findings on surgical outcome (morbidity, mortality rate).
3. To study the impact of non-concordance findings on surgical plan.

MATERIALS AND METHODS

This is a descriptive study. Data of complex congenital heart patients who had undergone heart surgery during 2013-2015 at Siriraj Hospital were retrospectively reviewed. We excluded palliative surgery cases (systemic to pulmonary shunt, PA banding), patients over 15 years old and missing data patients. A total of 300 patients were reviewed. The first stage palliative surgery cases were excluded because this procedure underwent without cardiopulmonary bypass support and we performed systemic to pulmonary shunt through thoracotomy incision which might limit intraoperative finding. The adult complex congenital heart patients were excluded because this group of patients have higher risk due to delay in surgery.

We reviewed inpatient and outpatient documents, operative notes and preoperative transthoracic echocardiographic reports. Preoperative echocardiogram was performed by pediatric cardiologist and/or fellow in pediatric cardiologist under the supervision of a certified pediatric cardiologist. Preoperative transthoracic echocardiographic reports were assessed on their concordance based on the intraoperative findings. Data that is deemed concordant must have all the data as listed in Fig 1 and correlate with intraoperative findings. In the non-concordance data group, the percentages of procedural change from preoperative plan due to the new findings were calculated. Procedural change is defined as change of cannulation technique from preoperative planning or having additional procedure performed. For example, persistent left sided superior-vena cava (SVC) that was found intra-operatively and additional left SVC cannulation that had to be performed. This was considered a change of cannulation technique. For change of intraoperative decisions that were not the result of different preoperative echocardiographic report, these were not included in this study. The concordance data and non-concordance data groups were analyzed to find the differences between demographic data, morbidity and mortality rate, cardiopulmonary bypass time and aortic cross clamp time.

Quantitative data was presented in median and range. Qualitative data was presented in number and percentage. In inferential statistics, Chi-square test was used for qualitative data and t-test/Mann Whitney U-test were used for quantitative data. P-value < 0.05 was used as a cut-off point of statistical significance. SPSS

V18.0 was used to analyze data.

Ethical approval for our clinical study was obtained by human research protection unit of Siriraj Hospital. (Si 248/2016)

RESULTS

300 cases were included in the study. Median age of patients is 21.5 months ranging from 2 days to 15 years old. Most cases were Tetralogy of Fallot (TOF), Univentricular heart disease and double outlet of right ventricle as shown in Table 1.

Among these patients, 77.7% (233 patients) of preoperative transthoracic echocardiography correlated to the intra-operative findings. In 22.3% of patients (n= 67), transthoracic echocardiographic findings differed from intraoperative findings. Systemic venous drainage (i.e. missing left superior vena cava (SVC), abnormal SVC drainage) were found to be the most common non-concordant findings. Second most common non-concordant findings were that of the coronary artery pattern (Table 2) which was found in all our patients with transposition of great arteries (TGA). So in TGA patients, echocardiography had accurately report type

TABLE 1. Patient characteristics.

	Total (n=300)	Echo concordant group (n=233)	Echo non-concordant group (n=67)	*p*-value
Age, months	21.5 (.07, 180)	22 (.07, 175)	20 (.27, 180)	0.878
Median (Min, Max)				
Preoperative Diagnosis, n (%)				
				0.293
TOF	86 (28.7%)	68 (29.2%)	18 (26.9%)	
TGA	21 (7%)	13 (5.6%)	8 (11.9%)	
DORV	25 (8.3%)	16 (6.9%)	9 (13.4%)	
PA/IVS	3 (1%)	3 (1.3%)	0 (0%)	
Truncus	15 (5%)	10 (4.3%)	5 (7.5%)	
TAPVR	14 (4.7%)	11 (4.7%)	3 (4.5%)	
PAPVR	7 (2.3%)	5 (2.1%)	2 (3.0%)	
AV canel	27 (9%)	17 (7.3%)	10 (14.9%)	
Ebstein	1 (0.3%)	1 (4%)	0 (0%)	
AP Window	1 (0.3%)	1 (4%)	0 (0%)	
CoA	14 (4.7%)	12 (5.2%)	2 (3.0%)	
ALCAPA	3 (1%)	3 (1.3%)	0 (0%)	
HLHS	8 (2.7%)	8 (3.4%)	0 (0%)	
TA	17 (5.7%)	16 (6.9%)	1 (1.5%)	
UVH	40 (13.3%)	33 (14.2%)	7 (11.4%)	
Others	18 (6%)	16 (6.9%)	2 (3.0%)	0.731
Urgent surgery, n (%)	(n=294)	(n=228)	(n=66)	
Elective	263 (89.5%)	204 (89.5%)	59 (89.4%)	
Urgent	29 (9.9%)	22 (9.6%)	7 (10.6%)	
Emergency	2 (0.7%)	2 (0.9%)	0 (0%)	
Redo operation	(n=300)	(n=233)	(n=67)	0.013
	32 (10.7%)	31 (13.3%)	1 (1.5%)	

Abbreviations: TOF=Tetralogy of Fallot, TGA=Transposition of great artery, DORV=Double outlet right ventricle, PA/IVS=pulmonary atresia/intact ventricular septum, Truncus=Truncus arteriosus, TAPVR=total anomalous pulmonary venous return, PAPVR=partial anomalous pulmonary venous return, AV canal=Common AV canal, AP window=Aortopulmonary window, CoA=Coarctation of aorta, ALCAPA=anomalous left coronary origin from pulmonary artery, HLHS=hypoplastic left heart syndrome,TA=Tricuspid atresia, UVH=univentricular heart disease

of coronary artery 62 % (13 patients from total 21). In non-concordant data group, 24 from 67 patients (35.8%) had their operative procedures changed from the preoperative plan. Cannulation technique was changed in 6 patients (9%).

Most common non-concordant diagnosis between preoperative echocardiographic reports and intraoperative findings was complete atrioventricular canal defects (complete AV canal) and followed by TOF as show in Table 3.

Demographic data between the two groups were similar, No statistical differences were found except for rates of redo-operation which was higher in concordant data group (13.3% VS 1.5%) as shown in Table 1. Redo-operation in this study mean that patient who underwent operation through previous incision.

For the analysis of intraoperative data, cardiopulmonary bypass time was found to be longer in non-concordant data group but p-value did not meet statistical significance. Morbidity, 30-day mortality, overall mortality were not different between two groups (Table 4).

TABLE 2. Preoperative TTE anatomical non-concordance.

Types of non-concordance	N = 54	Percent
Systemic vein drainage	19	35.19%
Coronary artery pattern	17	31.48%
Pulmonary vein drainage	6	11.11%
RVOT	3	5.56%
Valvular PS→Good size pulmonic valve	2	
Subvalve PS→No subvalvular obstruction	1	
Others	9	16.67%
Missed ASD secundum	1	
4→3 leaflets truncal valve	1	
Missed cortiratum	1	
Left-sided→Right-sided arch	1	
Mild→Severe hypoplastic LV	1	
Missed AP window	1	
Missed vegetation in RVOT	2	
Mild→Sever MR, TR	1	

TABLE 3. Non-concordance by pre-operative TTE.

Wrong diagnosis (Preoperative diagnosis)	Intraoperative diagnosis	N = 14	Percent
		5	
TOF	DORV	4	35.71%
	VSD/PS	1	
Complete AV canal		6	
	Partial AV canal	4	42.86%
	Type C → Type A	2	
Transitional AV canal		1	7.14%
Truncus arteriosus		2	14.29%

TABLE 4. Clinical outcome between echo groups.

	Echo concordant group (n=233)	Echo non-concordant group (n=67)	*p*-value
Op time, min	(n=229)	(n=65)	
Median (Min, Max)	175 (55, 565)	190 (90, 410)	0.095
CPB time	(n=222)	(n=67)	
Median (Min, Max)	95 (23, 394)	110 (41, 215)	0.056
AoX time	(n=187)	(n=63)	
Median (Min, Max)	62 (7, 237)	74 (19, 164)	0.141
Complication rate, n (%)	90 (38.8%)	25 (37.3%)	0.939
Death rate, n (%)	13 (5.6%)	5 (7.5%)	0.565
30 days mortality, n (%)	10 (4.3%)	3 (4.5%)	1.000

1. Situs position/Atrial - ventricle relationship/ ventricle –great vessel relationship
2. Systemic vein drainage
3. Pulmonary vein drainage
4. Atrioventricular valve anatomy and function
5. Aortic and pulmonic valve anatomy and function
6. Truncal valve anatomy and function (in Truncus arteriosus)
7. Shunt in atrial level/ ventricular level/ Great vessel level
8. RV outflow tract
9. McGoon ratio (in TOF, PA/VSD, Univentricular heart)
10. LV outflow tract
11. Coronary anatomy (in TGA, TOF and PA/VSD)
12. Great vessels relationship
13. Aortic arch anatomy and position
14. LV and RV function
15. Assessment of pulmonary hypertension
16. Proximal descending aorta anatomy and gradient across stenosis lesion (in Coarctation of aorta)

Abbreviations: TOF=Tetralogy of Fallot, TGA=Transposition of great artery

Fig 1. Criteria for completeness of echocardiography report.

DISCUSSION

Preoperative transthoracic echocardiography provided concordant data in 77.7% of our study group. Approximately one third of patients (32.3%) who had non-concordant data, did not undergo surgery as planned preoperative and approximately one tenth of patients (9%) had to change the cannulation technique. The most common differing data was information on systemic venous drainage such as Lt SVC. Second most common non-concordant data were details of the coronary artery pattern. All non-concordant data found in our TGA patients were error in coronary artery pattern. However, differing preoperative data from transthoracic echocardiography did not affect the morbidity and mortality rates of patients.

Although no statistical significant effect of non-concordant preoperative data was found, there was one Tetralogy Of Fallot (TOF) patient who underwent total repair and preoperative echocardiography did not demonstrate any left ventricular hypoplasia. After the operation, he needed extracorporeal membrane oxygenation (ECMO) insertion and reoperation.

Compared to other studies, Our study showed higher ratio of non-concordant data (32.3 % VS 2-7%).[11-14] This may be because our study was a retrospective study and we used only 2D transthoracic echocardiography. Furthermore, some of primary investigators were fellows who have less experience compared to certified pediatric cardiologist. With respect to non-concordance data to surgical procedure,[11-14] our result was comparable with other studies with the rate of changed procedure about 30-40% without effect to surgical outcome, such as study by Tworetzky W which was discovered in 42.1% (8 in 19 cases)[12] or study by Pfammatter JP in 33.3% (4 in 12 cases).[11]

Our study found a high rate of non-concordant data in coronary artery pattern different from other studies which suggested that coronary anatomy could be accurately assessed by preoperative echocardiogram (62% VS 86%).[15] This finding may be affected by retrospective design. Improvement of technology in echocardiography machine may be ameliorate this problem.

We also noticed that patients who required staged procedures tend to have a higher rate of concordant preoperative echocardiographic data. This may be due to the fact that these cases have had some data from previous intraoperative findings and may have also gotten multiple echocardiographies before surgery. Cardiologists might also pay more attention to those redo cases due to awareness of its complexity in surgery.

Limitations of this study were its retrospective design and high distribution of diseases. So it is difficult to compare between groups of patients. Secondly, changing surgical procedures were also decided subjectively by individual surgeons. Lastly, Interpersonal variability between surgeons performing the operation is another uncontrolled factor in our study. Future study should be more disease specific and prospective design.

CONCLUSION

Transthoracic echocardiography is valuable tool that provides a lot of details on anatomical and physiological data. However, in some complex congenital heart diseases especially in TGA patients whom we not sure about coronary artery anatomy, patients may still need additional investigations such as cardiac catheterization, CT scan, cardiac MRI in order to get adequate anatomical and physiological data for planning the surgical procedure and counselling purposes.

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