Limitation of Transthoracic Echocardiography in the Diagnosis of Congenital Heart Diseases

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Abstract

Nowadays, it has been widely accepted that echocardiography is the most efficient, non invasive diagnostic tool to diagnose congenital heart diseases. However, cardiac catheterization remains the gold standard to diagnose and obtain hemodynamic data prior to cardiovascular surgery. In order to find out the accuracy of transthoracic echocardiography in relation to the anatomical diagnosis of congenital heart diseases, 175 consecutive patients who underwent diagnostic cardiac catheterization during January 1999 to December 1999 were reviewed. All of them had complete echocardiographic studies prior to the procedure. The male to female ratio was 1.06:1. The median age at the time of echocardiography was 3.36 (0.01-28.8) years old. The indications of the cardiac catheterization were to demonstrate cardiovascular anatomy 64 per cent, to obtain pulmonary artery pressure and pulmonary vascular resistance 13.7 per cent, and to get both information 22.3 per cent. Tetralogy of Fallot (23.4%) was the most frequent cardiac malformation, followed by complex congenital heart diseases (22.3%), simple left to right shunt (12%), pulmonary atresia with ventricular septal defect (8.6%), tricuspid atresia (5.7%), simple d-transposition of great arteries (4%), etc. From cardiac catheterization; 49 cases (28%) revealed additional data which were surgically important, 3 cases (1.7%) resulted in different diagnoses, and 3 cases (1.7%) revealed additional information which was not surgically important. Inadequate imaging technique (36 cases, 65.5%) and limitation of technique (19 cases, 34.5%) were the reasons for missing anatomical findings of transthoracic echocardiography. Age at the time of echocardiography was not a significant factor affecting the accuracy. Persistent left superior vena cava, multiple aorto-pulmonary collateral arteries, pulmonary artery anatomy, and coronary artery anatomy were the most frequent cardiac lesions misdiagnosed by transthoracic echocardiography that were somewhat surgically important. The incorrect echocardiographic diagnoses were aorto-pulmonary window, patent ductus arteriosus, and vascular ring. Thorough and extensive echocardiographic scanning coupled with cooperative or adequately sedated patients by an experienced

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operator using an efficient echocardiographic machine might improve the accuracy of transthoracic echocardiography in the diagnosis of congenital heart diseases.

Key word : Transthoracic Echocardiogram, Congenital Heart Diseases

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Echocardiography has been dramatically advanced in technology since 1980 from single plane M-mode to color flow imaging technique[1-4]. Transesophageal echocardiography, three dimensional echocardiography, and intravascular imaging are adjunctive technologies for additional information in the diagnosis of congenital heart diseases [5,6]. These make echocardiography the most crucial noninvasive diagnostic tool for congenital heart diseases in general. Unfortunately, due to limitation in the size of pediatric patients and the availability of the equipment, transthoracic echocardiography remains the standard diagnostic tool for most of the congenital heart diseases in children. Nowadays, an increasing number of congenital heart lesions are successfully operated on using the transthoracic echocardiographic data[7]. There are several factors affecting the accuracy of transthoracic echocardiography. Inadequate imaging technique, incorrect interpretation, or limitation of the technique were claimed to be the causes of the errors[8]. In this study, using cardiac catheterization as the gold standard, we intend to find the accuracy and limitation of transthoracic echocardiography in our institution. The technique might be able to be improved, hence affecting the outcome.

PATIENTS AND METHOD

The cardiac catheterization database was reviewed. One hundred and seventy five consecutive patients underwent diagnostic cardiac catheterization during January 1999 to December 1999. The cardiological file, cardiac catheterization file, and echocardiographic tapes of all the patients were reviewed. Demographic data, transthoracic echocardiographic data, indications for cardiac catheterization, and cardiac catheterization data were collected. The data was analyzed statistically to find out the accuracy of transthoracic echocardiography using cardiac catheterization as the gold standard.

Statistical analysis

All categorical data are expressed as frequency and percentage. Measured data were presented as median and range. The difference between groups was assessed by using the Mann-Whitney U test. A p-value less than or equal to 0.05 is considered for significant difference.

RESULTS

In the total of 175 patients, the male to female ratio was 1.06:1. The median age was 3.36 (0.01-28.8) years old. The number of cardiovascular lesions are demonstrated in Table 1. The indications of cardiac catheterization were to clarify the cardiovascular anatomy in 112 cases (64%), to measure pulmonary artery pressure and resistant 24 cases (13.7%), and to obtain both informations 39 cases (22.3%). The result showed there were 55/175 cases (31.4%) who had additional or different diagnoses from cardiac catheterization. Forty nine cases (28%) had additional information with surgical importance from cardiac catheterization. In three cases (1.7%), additional information without surgical importance was found, and in the other 3 cases, the results indicated different diagnoses. The details are shown in Table 2 and 3. There was no statistically significant difference in age at the time of echocardiography between the fifty five patients and the rest of the patients (median 4.3, range 0.01- 24.9 years

Table 1. Number of cardiovascular lesions in this study.

Congenital heart defects	Frequency	Per cent
TOF	41	23.4
Complex CHD	39	22.3
Simple L to R shunt	21	12.0
PA, VSD	15	8.6
TA	10	5.7
d-TGA	7	4.0
CoA	5	2.9
VSD, DCRV	4	2.3
d-TGA, VSD, PS	4	2.3
Other	29	16.6
Total	175	100.0

TOF = tetralogy of Fallot, CHD = congenital heart disease, L to R = left to right shunt, PA, VSD = pulmonary atresia and ventricular septal defect, TA = tricuspid atresia, d-TGA = dextro transposition of great arteries, CoA = coarctation of aorta, DCRV = double chamber right ventricle, PS = pulmonary stenosis

Table 2. Cardiovascular anatomy which was missed by transthoracic echocardiogram.

Cardiovascular anatomy	No
With surgically important (49)	
Lt SVC	12
MAPCAs	12
Coronary artery anatomy	9
Pulmonary artery anatomy	8
Pulmonary venous return	2
PDA	2
Miscellaneous	4
Without surgically important (3)	
Retroaortic innominate vein	3
Different diagnosis (3)	
AP window	1
Vascular ring	1
PDA	1

Lt SVC = persistent left superior vena cava, MAPCAs = multiple aorto-pulmonary collateral arteries, PDA = patent ductus arteriosus, AP window = aorto-pulmonary window

Table 3. Comparison of echocardiographic and cardiac catheterization diagnosis.

Echo. diagnosis	Cardiac cath. diagnosis								Total	
	correct Dx		additional information with surgically important		additional information without surgically important		Different Dx			
	No.	%	No.	%	No.	%	No.	%	No.	%
TOF	30	73.2	10	24.4	1	2.4	0	0	41	100.0
simple L to R shunt	18	85.7	1	4.8	0	0	2	9.5	21	100.0
complex CHD	24	61.5	15	38.5	0	0	0	0	39	100.0
PA, VSD	4	26.7	10	66.7	1	6.7	0	0	15	100.0
TA	9	90	1	10	0	0	0	0	10	100.0
d-TGA	5	71.4	2	28.6	0	0	0	0	7	100.0
CoA	3	60.0	2	40.0	0	0	0	0	5	100.0
VSD, DCRV	4	100.0	0	0	0	0	0	0	4	100.0
d-TGA, VSD, PS	1	25.0	3	75.0	0	0	0	0	4	100.0
others	22	75.8	5	17.2	1	3.4	1	3.4		100.0

old and median 3.2, range 0.02- 28.8 years old: p = 0.36). The causes of mistakes were inadequate imaging technique 36/55 cases (65.5%) and limitation of technique 19/55 cases (34.5%).

DISCUSSION

The length of time in an open-heart surgical procedure is an important determinant for a successful outcome. Unexpected intra-operative findings should be strenuously avoided by a properly pre-operative diagnostic evaluation. However, cardiac catheterization in small infants carries a considerable risk. Therefore, many children with congenital heart diseases would benefit if a pre-operative evaluation, purely from noninvasive diagnostic method, yields a comparable result to that of an invasive diagnostic assessment. More and more complex heart diseases have been successfully operated on resulting in a better quality of life and longevity.

There were a number of patients with complicated heart diseases who underwent cardiac catheterization as the pre-operative evaluation as shown in Table 1. In our institution, echocardiography is the only pre-operative non-invasive imaging technique used in most of the left to right shunt lesions, tetralogy of Fallot, TGA, CoA, etc. Only some of the simple cardiac lesions, e.g. left to right shunt (those beyond 2 years old with clinical evidence of significant pulmonary hypertension), and tetralogy of Fallot (those whose anatomy was unclear from echocardiogram, eg. coronary arteries) underwent cardiac catheterization. Pfammatter JP. reported 68 per cent of the total open-heart operations relying on echocardiogram alone with undiagnosed findings 8.5 per cent[7]. In our institution, the number of undiagnosed findings is pretty high (31.4%) This could be due to the higher ratio of more complicated cardiac lesions in our study and we did not include the ones who were operated on without cardiac catheterization whose imaging from echocardiogram were good enough. The number of cardiac catheterization to demonstrate cardiac anatomy is also quite high (64% of total number of diagnostic cardiac catheterization). These issues might be improved by better echocardiographic imaging and interpretation.

From echocardiogram, the wrong diagnoses were found in three cases (1.7%). The first one was aorto-pulmonary window, which could have been detected by thorough scanning in different views (short axis, suprasternal notch, and subcostal coronal views) with color flow mapping[9]. A vascular ring was a difficult diagnosis to make by echocardiogram. Due to various anatomical abnormalities, carefully scanning in suprasternal notch view could reveal a few types of vascular ring. Magnetic resonance imaging (MRI) is now the diagnostic method of choice for vascular ring and demonstrates associate abnormalities in tracheobronchial tree[10].

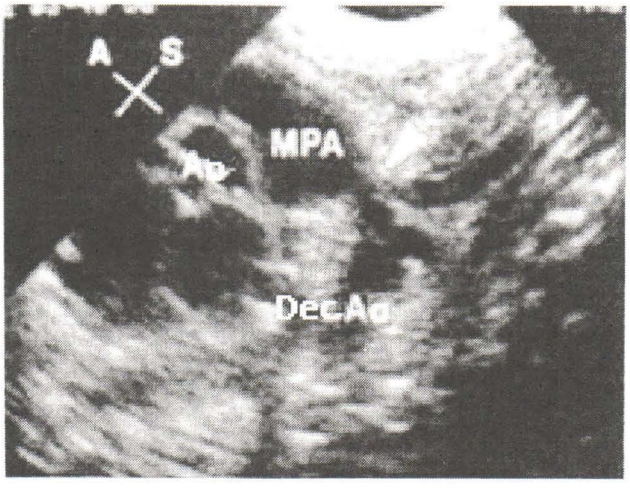

Fig. 1. Demonstrates high parasternal or ductal cut view. Arrow points at PDA. A = anterior, S = superior, Ao = aorta, MPA = main pulmonary artery, DecAo = descending aorta.

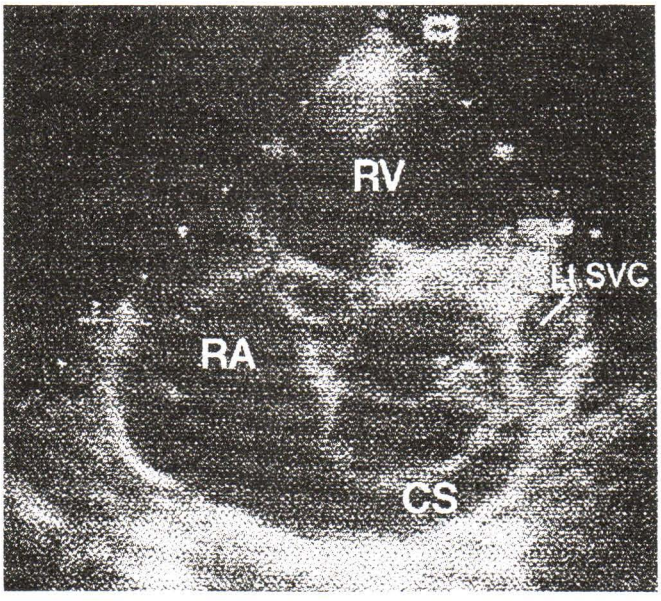

Fig. 2. Demonstrates modified parasternal short axis view. CS = coronary sinus, LtSVC = left superior vena cava, RA = right atrium, RV = right ventrcle.

Patent ductus arteriosus (PDA) is the simple cardiovascular defect that could have been easily missed by echocardiogram, even with color flow mapping, especially in patients with pulmonary hypertension or the tortuous course PDA[8,11]. Thorough scaning in parasternal short axis, suprasternal notch, and high parasternal or ductal cut views (half way between the short axis and suprasternal notch views) with Doppler echocardiogram and color flow mapping could demonstrate a better picture of PDA, as shown in Fig. 1. Additional information from cardiac catheterization was found in 29.7 per cent of cases. Some of these might affect the surgical options and outcome. Persistent left superior vena cava (LtSVC) was found to be associated with tetralogy of Fallot and complex CHD. To avoid missing the diagnosis, the operator might have kept in mind that LtSVC can be associated with simple heart lesions and drain into the coronary sinus in the majority of cases. On the routine scanning, whenever the coronary sinus is prominent, one should thoroughly scan in suprasternal notch view to look for the left innominate vein. If the left innominate vein is small or absent, the transducer should be tilted leftward from the standard parasternal short axis view[9,12] as in Fig. 2. It is widely accepted that echocardiography has limitation to image MAPCAs. Transesophageal echocardiogram provides a better image of coronary artery anatomy, proximal pulmonary artery anatomy and pulmonary venous return[13,14].

In summary: Diagnostic cardiac catheterization is still crucially necessary in pre-operative cardiovascular surgery assessment of some congenital heart diseases. Thorough transthoracic echocardiographic scanning in extensive views by an experienced operator using an efficient echocardiographic machine may be able to produce better data and reduce the number of cardiac catheterizations.

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ข้อจำกัดในการวินิจฉัยโรคหัวใจพิการแต่กำเนิดด้วยคลื่นเสียงสะท้อนความถี่สูงทางหน้าอก

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ในปัจจุบันเป็นที่ยอมรับกันอย่างกว้างขวาง ว่าการตรวจด้วยคลื่นเสียงสะท้อนความถี่สูงเป็นวิธีการตรวจที่ไม่เป็นอันตรายที่ใช้ได้ดีที่สุดในการวินิจฉัยโรคหัวใจแต่กำเนิด อย่างไรก็ตามการตรวจสวนหัวใจยังถือเป็นวิธีที่เชื่อถือได้มากที่สุดในการวินิจฉัยและหาข้อมูลทางการไหลเวียนโลหิตก่อนการผ่าตัดหัวใจและหลอดเลือด การศึกษานี้เพื่อหาความถูกต้องแม่นยำของการตรวจคลื่นสะท้อนความถี่สูงทางหน้าอกในการวินิจฉัยโรคหัวใจแต่กำเนิด ได้ศึกษาในผู้ป่วยทุกรายที่มารับการตรวจสวนหัวใจ ที่รพ.ศิริราช ตั้งแต่มกราคม ถึง ธันวาคม 2542 มีผู้ป่วยทั้งหมด 175 ราย ทุกรายได้รับการตรวจด้วยคลื่นสะท้อนความถี่สูงมาก่อน พบว่าเป็นผู้ป่วยชาย:หญิง ในอัตราส่วน 1.06:1 อายุเฉลี่ยเมื่อทำการตรวจคลื่นเสียงสะท้อนความถี่สูง 3.36 (0.01–28.80) ปี ข้อบ่งชี้ในการทำคือ เพื่อการวินิจฉัย 64% เพื่อวัดความดันและหาความต้านทานของเส้นเลือดในปอด 13.7% และเพื่อหาทั้ง 2 อย่าง 22.3% ในจำนวนนี้พบเป็นโรค tetralogy of Fallot 23.4% ตามด้วย complex congenital heart deseases 22.3%, simple left to right shunt 12%, pulmonary atresia with ventricular septal defect 8.6% tricuspid atresia 5.7%, dextrotransposition of great arteries 4% เป็นต้น ผลการตรวจสวนหัวใจพบว่า 49 ราย (28%) พบข้อมูลเพิ่มเติมซึ่งมีผลต่อการผ่าตัด, 3 ราย (1.7%) มีการวินิจฉัยไม่ตรงกัน, อีก 3 ราย (1.7%) พบข้อมูลเพิ่มเติมไม่มีผลต่อการผ่าตัด ซึ่งเข้าใจว่าเป็นผลจากเทคนิคในการทำ echocardiogram 36 ราย (65.5%) และจากขีดจำกัดของวิธีการตรวจด้วยคลื่นเสียงสะท้อนความถี่สูง 19 ราย (34.5%) อายุช่วงที่ทำการตรวจไม่มีผลต่อความแม่นยำในการวินิจฉัย Persistent left superior vena cava, multiple aorto–pulmonary collateral arteries , เส้นเลือดดำที่ไปปอดและเส้นเลือดแดงที่ไปเลี้ยงหัวใจ เป็นข้อมูลที่ไม่เพียงพอหรือขาดหายไปจากการตรวจด้วยคลื่นเสียงสะท้อนความถี่สูงที่มีผลต่อการผ่าตัด Aorto–pulmonary window, Patent ductus arteriosus, vascular ring เป็น 3 ภาวะที่วินิจฉัยไม่ถูกต้อง การตรวจอย่างละเอียดโดยการวาง probe ในตำแหน่งต่างๆ ในผู้ป่วยที่ให้ความร่วมมือหรือหลับสนิทตลอดจนประสบการณ์ในการตรวจคลื่นเสียงสะท้อนความถี่สูง และเครื่องตรวจที่มีประสิทธิภาพ จะช่วยให้การวินิจฉัยโรคหัวใจแต่กำเนิดด้วยคลื่นเสียงสะท้อนความถี่สูงถูกต้องแม่นยำยิ่งขึ้น และยังลดจำนวนการตรวจสวนหัวใจด้วย

คำสำคัญ : การตรวจหัวใจด้วยคลื่นเสียงสะท้อนความถี่สูง, โรคหัวใจพิการแต่กำเนิด

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