

Echocardiographic Assessment of Myocardial Performance Index After Complete Surgical Correction of Tetralogy of Fallot

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Running title: Echocardiographic Assessment of Tetralogy of Fallot Repair

Abstract:

Background: Cardiac function may change following complete surgical correction of Tetralogy of Fallot (TOF) and measures that can assess these changes are either invasive or very expensive.

Objectives: This study aim was to investigate the use of Doppler echocardiography as a simple, inexpensive and reproducible method for assessment of cardiac function.

Methods: In a case-control study 30 children who underwent surgical correction of TOF and visited the children's clinic in Ali Asghar Hospital in Zahedan between September 2005 and March 2007 were compared with 30 healthy age and sex matched children. All participants underwent physical examination, chest radiography and electrocardiography (ECG) before echocardiography. Cases who did not have any clear cardiac signs and whose surgical repair had been performed at least 6 months ago entered the study. Echocardiography was performed for both groups. Data were analyzed using the SPSS software and suitable statistical tests.

Results: Right ventricular myocardial performance index (MPI), mean right ventricular isovolumic relaxation time (IRT) and isovolumic contraction time (ICT) and mean RV PEP/ET were higher in cases than controls ($p < 0.001$, 0.014 , < 0.001 and 0.0001 , respectively). There were no significant differences between mean RV E/A between cases and controls ($p = 0.999$). Mean left ventricular MPI and ICT were higher in cases than controls ($p < 0.001$). Mean left ventricular IRT was not different between the two groups ($p = 0.501$).

Conclusion: The findings of this study showed that LV and RV dysfunction ensue complete surgical correction of TOF. Therefore, right and left ventricular performance indexes can serve as valuable parameters in assessing cardiac performance in such patients.

Keywords: echocardiography, Tetralogy of Fallot, myocardial performance index, children

Introduction

Tetralogy of Fallot (TOF) is one of the most common cyanotic congenital heart diseases with a prevalence of 0.26-0.8 in 1000 live births. TOF constitutes 10 percent of congenital heart diseases. The severity of right ventricular outflow obstruction

determines the onset of symptoms, degree of cyanosis and amount of right ventricular hypertrophy. The best age for surgical correction is 4-12 months. Most patients enjoy a symptom free and normal life with good function. However, there is long-term morbidity with potentially le-



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thal complications like arrhythmia and sudden death. It is necessary to follow patients who undergo surgical repair of TOF by imaging to obtain adequate information about residual anatomical problems, degree of pulmonary stenosis or regurgitation and systolic and diastolic function of both ventricles. (1, 2)

Echocardiography is a suitable tool to assess myocardial performance index (MPI). MPI is calculated by dividing the sum of ICT (isovolumic contraction time) and IRT (isovolumic relaxation time) by ET (ejection time). Cardiac function may change following complete surgical correction of TOF. This study, therefore, investigates the use of Doppler echocardiography as a simple, inexpensive and reproducible method for assessment of cardiac function. Although assessment of right ventricular function is important in the management of children with CHD, imaging techniques are limited by the special geometric shape of the right ventricle. (3) In these researches, myocardial systolic and diastolic function was measured using Tei Index or MPI. (4, 5) In a study by Salehian et al in patients with transposition of great vessels, it was stated that in a systemic RV MPI can assess the global function of the ventricle and estimate its EF with an acceptable accuracy. (6) In another study Schwerzman et al used a multivariate regression analysis and found out that MPI is not affected by the degree of pulmonary insufficiency, presence of tricuspid insufficiency, or the duration of QRS and concluded that MPI is a simple and reliable index for assessment of right ventricular function after complete surgical correction of TOF. (7) Andrea et al found out that following surgical correction of TOF, tissue Doppler echocardiography can measure exertional MPI and predict patients at high risk of ventricular arrhythmia. (8) Cheung et al reported that increased MPI reflects decreased right ventricular EF and exertional capacity in patients after surgical correction of TOF. (9) In a study by Liang et al it was mentioned that the following surgical correction of TOF, increased right ventricular volume load can negatively affect left ventricular function through creating global mechanical dyssynchrony. (10) In yet another study by Cannesson et al, it was shown that the measurement of MPI using a tissue method can rapidly identify changes in the contraction quality of left ventricle but this is influenced by changes in both preload and afterload. (11) The aim of this study was to show that myocardial function improves following surgi-

cal correction of TOF. This is the first study of its kind in Iran and similar studies are few in other countries. We hope this study can provide more information about complications of surgery in patients that will enable us to give the chance for a less limited life style for our patients.

Materials and methods

In a case-control study 30 children who underwent surgical correction of TOF and visited the children's clinic in Ali Asghar Hospital in Zahedan between September 2005 and March 2007 were compared with 30 healthy age and sex matches who had normal echocardiography. All participants underwent physical examination, chest radiography and electrocardiography (ECG) before echocardiography was done. Controls that had a clear cardiac signs, known dysrhythmia, or confounding disease were excluded and cases whose date of surgical repair had been at least 6 months previously entered the study. Echocardiography was performed for both groups using the same device (Challenge 70000, made in Italy using 2.5, 3.5 and 5 MHZ transducers) by one pediatric cardiologist. Echocardiography was performed in supine position and without breath holding by 2D, M-Mode and Doppler methods and the average value of each parameter was calculated in three cardiac cycles. M-Mode images were obtained at the level of the tips of mitral valve cusps at the parasternal line. Using the M-Mode interventricular septum and left ventricular posterior wall thickness was measured in systole and diastole as well as left ventricular end-systolic volume, left ventricular end-diastolic volume, ejection fraction and shortening fraction. Pulsed-Doppler was used to measure velocity of blood through valves and A- E-velocity, velocity, Ejection time and pre Ejection time and E/A, PEP/ET ratios were measured. Isovolumetric relaxation time (IVRT) was measured by placing a probe in apical five chamber position. M-Mode and Doppler views were recorded on a paper at a speed of 50 mm/sec. An interval is defined as the time from the start of flow of blood from mitral or tricuspid valve and equals sum of IVRT, ICT and ET. Ejection time (b) is the time it takes for blood to leave right or left ventricle. Eventually the combined MPI was calculated using the formula $(a-b)/b$.

The study protocol was approved in research ethics committee of Zahedan University of Medical Sciences and informed consent was obtained from parents before enrollment in the study.

Data analysis

Data were analyzed using the SPSS software and X² and t- tests.

Results

The case and control groups had similar sex distribution (10 girls and 20 boys in each group. Cases had an average age of 7.11±2.7 years and controls had an average age of 2.75±7.1 years (p=0.981). The average duration of post operative period was 37.86±18.27 months. Mean MPI was 0.66±0.17 in the case group and 0.31± 0.05 in the control

group (p<0.001). Mean right ventricular IRT was 108 ±22 milliseconds and 96±11 milliseconds in the case and control groups, respectively (p=0.014). Mean right ventricular ICT was 66±27 milliseconds and 35±17 milliseconds in the case and control groups, respectively (p<0.001). Mean right ventricular PEP/ET was 0.48±0.12 in the case group and 0.28±0.02 in the control group (p=0.0001). Mean right ventricular E/A ratio was 1.4±0.83 in the control group and 1.4±0.31 in the control group (p=0.999). Mean right ventricular DT was 113±27 and 119±18 in the case and control groups, respectively (p=0.321) (Table 1).

Table 1: Statistical parameters measured in right ventricle in each study group

Echocardiographic Parameter	Group	Mean	SD	n	p value
MPI	Case	0.66	0.17	30	0.0001
	Control	0.31	0.049	30	
IRT	Case	108	22	30	0.013
	Control	96	11	30	
ICT	Case	66.3	27	30	0.0001
	Control	35.3	17	30	
E/A	Case	1.4	0.8	30	0.999
	Control	1.4	0.3	30	
DT	Case	113	27	30	0.320
	Control	119	18	30	
PEP	Case	118	19	30	0.0001
	Control	76	7.9	30	
ET	Case	252	40	30	0.179
	Control	264	23	30	
PEP/ET	Case	0.48	0.11	30	0.0001
	Control	0.28	0.02	30	

Mean left ventricular MPI was 0.61±0.19 in the case group and 0.32±0.05 in the control group (p<0.001). Mean left ventricular IRT was 97±19 and 94±11 milliseconds in the case and control groups, respectively (p=0.501). Mean left ventricular ICT was 56±28 and 25±10 milliseconds in the case and control groups, respectively (p<0.001). Mean left ventricular PEP/ET was 0.46±0.09 in the case group and 0.28±0.02 in the control group (p<0.001). Mean left ventricular E/A ratio was 1.62±0.71 in the control group and 1.85±0.47 in the control group (p=0.15). Mean left ventricular DT was 116±22 and 120±15 in the case and control

groups, respectively (p=0.426) (Table 2).

Discussion

Most methods that are used to assess the changes in cardiac function following surgical correction for TOF are either invasive or very costly. This study was carried out to assess the cardiac function using echocardiography that is simple, inexpensive and reproducible. MPI has been increasingly used to assess both systolic and diastolic function of ventricles and is defined as the sum of isovolumetric cardiac activity divided by ejection time and could be measured for

Table 2: Statistical parameters measured in left ventricle according to the study groups

Echocardiographic Parameter	Group	Mean	SD	n	p value
MPI	Case	0.61	0.19	30	0.0001
	Control	0.32	0.051	30	
IRT	Case	97	19	30	0.500
	Control	94	11	30	
ICT	Case	56	28	30	0.0001
	Control	25	10	30	
PEP	Case	111	23	30	0.0001
	Control	75	5.2	30	
ET	Case	240	34	30	0.002
	Control	263	19	30	
PEP/ET	Case	0.46	0.09	30	0.0001
	Control	0.28	0.02	30	
DT	Case	116	22	30	0.426
	Control	120	15	30	
E/A	Case	1.6	0.7	30	0.152
	Control	1.1	0.4		

right and left heart separately. (12)

In the study by B.ocal on left ventricular MPI in patients treated with doxorubicin, MPI was higher in cases than controls, mainly due to increased IRT and decreased ET (ICT remained relatively constant).(13) In a study on the value of MPI in assessment of cardiac function following surgical repair of TOF, Abd El Rahman et al. showed that right and left ventricular function changes such that right ventricular MPI was unexpectedly below normal range (76.5%) resulting from reduced IRT; a finding that contradicts those of the present study. In the same study, left ventricular MPI was also observed to be less than normal due to reduced ICT; however, in our study, left ventricular ICT increased following surgery.(3) In another study by Abd EL Rahman et al on the relation between left ventricular asynchrony and right bundle branch block following surgery for TOF, patients with right bundle branch block evidenced by ECG showed significantly higher MPI associated with regional and global left ventricular dysfunction. This can explain the increased MPI in our study since majority of our patients had evidence of bundle branch block.(14) In the year 2000, Abd EL Rahman et al studied the relation between right

ventricular function and QRS duration in patients with TOF whose pulmonary regurgitation was completely corrected surgically. They found out that MPI was increased more significantly in patients with severe pulmonary regurgitation compared with patients with mild or moderate pulmonary regurgitation. This was due to reduced EF of right ventricle. They also observed a relationship between the size of the RV and the QRS duration. In our study there was only one case with sever pulmonary regurgitation.(5) Tatani et al believes that following surgical repair of TOF BNP may increase in relation to the size of right heart chambers and the severity of pulmonary insufficiency. In the same study, echocardiographic parameters of the patients increased much like our study.(15) Pilla et al stated that right ventricular dysfunction is observed in patients who undergo complete surgical repair of TOF; a finding that is in line with the findings of our study.(16) Kirsch e al reported that local myocardial injury following repair of TOF and transitional changes ensuing from pulmonary valve replacement can be assessed by echocardiography and that these findings can be confirmed by cardiac MRI and measurement of BNP. (17) Sachdev et al showed that RV diastolic dysfunction

can be demonstrated by echocardiography in the first week after surgery for TOF and that it is more severe if associated with transannular patch. (18) Andrea et al showed that in adults with delayed correction for TOF RV myocardial dysfunction exists despite normal Doppler echocardiography findings. In these patients tissue Doppler echocardiography can be highly valuable in predicting serious response and long-term assessment of cardiac reserve function (8).

Increased MPI in our study reflects simultaneous systolic and diastolic dysfunction in each of the ventricles after surgery for TOF. In other words, increased MPI shows global cardiac dysfunction. Increased IRT, that is diastolic function index, indicates a defect in ventricular relaxation. On the other hand, mean RV MPI in 93% of cases and mean LV MPI in 83.3% of cases was higher than same parameters in controls ($p < 0.05$). This means a more profound deterioration of RV function that is inherent in the pathophysiology of TOF. Mean PEP/ET showed significant difference in our study ($p < 0.001$) unlike mean E/A ($p > 0.05$). In our study, increased MPI explains global dysfunction of heart as well as residual abnormalities after surgery. In fact this index can guide in diagnosis of pathologic valvular insufficiency and residual anatomical abnormalities after complete surgical correction for TOF. Increased LV MPI, that indicates LV dysfunction, can be attributed to increased ICT duration, paradoxical movement of interventricular septum, myocardial fibrosis or preoperative hypoxia that through lodging of interventricular septum toward left ventricle due to volume overload in RV can diminish LV function.

As a conclusion, the findings of this study showed that RV and LV dysfunction exist following complete surgical repair of TOF. Since MPI is useful parameter in showing systolic and diastolic function of ventricles its increase can indicate persistence of morphological, anatomical and functional abnormalities after surgery for TOF.

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