



## Assessment Of Right Ventricular Contractile Function and Its Relation to Pulmonary Regurgitation by Echocardiography in Tetralogy Of Fallot Patients After Surgical Repair

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### Abstract

**Background:** Although advancement in teratology of fallot (TOF) surgical techniques, pulmonary regurgitation remains the frequent complication after TOF repair and the common risk factor for right and left ventricular dysfunction.

**Aim of study:** We sought to assess the right ventricular contractile function (RV-FAC, TAPSE, MPI, S' and IVA) with focusing on IVA to evaluate right ventricular contractile function that is unaffected by ventricular shape or loading condition.

**Patients and methods:** This study is a descriptive cross sectional study conducted in Echocardiography unit of Ibn-Alnafies Cardiac Center, Ibn-Albitar Cardiac Center & Baghdad Teaching Hospital in Baghdad Medical city during the period from 1st of September, 2018 to 31st of March, 2019 on 50 patients post TOF. The Tissue Doppler echocardiography was accomplished in regard to the American society of echocardiography. The severity of the pulmonary regurgitation was done by color and continuous Doppler studies.

**Results:** Means of right ventricle fractional area change and tricuspid annular plane systolic extraction of patients with TOF were significantly lower than controls, while mean myocardial performance index of TOF patients was significantly higher than controls. Means of global right ventricle systolic function and isovolumic acceleration of TOF patients were significantly lower than controls and significantly lower among TOF patients with severe pulmonary regurgitation. The validity results of isovolumic acceleration regarding right ventricle status of TOF patients were sensitivity (81.8%), and specific (96.4%).

**Conclusion:** The isovolumic acceleration assessed by Doppler echocardiography is valid tool in assessment of right ventricle for patients with teratology of Fallot after surgical repair.

**Keywords:** Teratology of Fallot, Pulmonary regurgitation, Isovolumic acceleration.

## Introduction

Pulmonary valve regurgitation has been recognized as one of the most important risk factors for both right and left ventricular performance after the repair of ToF. Pulmonary regurgitation may be well tolerated for several years but, depending on its severity, it results in a progressive RV dilation and dysfunction. The echocardiographic study of the RV after ToF surgery should include dimensional and volumetric measurements to determine the degree of segmental and global RV dilatation<sup>1</sup>. Echocardiographic quantitative parameter used to evaluate the right ventricular function are distinguished in geometrical and non-geometrical parameters. Geometrical parameters is measurement of fractional area changes (FAC) and is expressed as a percentage change of diastolic and systolic area of the RV inflow measured on an apical 4-chamber view optimized for the RV<sup>2</sup>. This method is based on geometric assumptions valid for the conical shape left ventricle that may not apply to the RV in general and especially to the RV in patients after ToF repair where the outflow tract is often markedly dilated. Non-geometric indices Tricuspid annular plane systolic excursion (TAPSE) measures the systolic excursion of the RV annular plane toward the apex. It is a very easy echocardiographic measurement, rapid to measure in a busy clinical setting, and is widely used in clinical practice even if its reliability is still controversial<sup>3</sup>. Myocardial performance index (MPI) is an easily measured index for the assessment of global heart function, combining both systolic and diastolic components<sup>4</sup>. Isovolumic acceleration time is a TDI derived parameter that defines the myocardial acceleration during isovolumic contraction of tricuspid lateral annulus and has been proposed as a preload-independent indicator of RV contractility<sup>5</sup>. pulmonary regurgitation severity should be done with color Doppler: a severe pulmonary regurgitation is recognizable on color Doppler flow as a large retrograde flow that persists beyond the first half of diastole invading the RV outflow tract. Quantification of pulmonary regurgitation severity is assessed more precisely using spectral Doppler. The regurgitant velocity profile expresses the pressure gradient between the main pulmonary artery and the RV during diastole. If pulmonary diastolic pressures are normal, peak velocity is not higher than 1/ms. A quantitative assessment of pulmonary regurgitation severity is based on the deceleration velocity of the regurgitant flow known as pressure half time (PHT), the time in milliseconds taken to reach half of the pressure gradient. PHT could be easily measured using

continuous wave Doppler. and values of PHT under 100/ms were a highly specific and significant index of severe pulmonary regurgitation<sup>6</sup>. S' velocity measures longitudinal RV contraction and is a surrogate of RV systolic function. s' is easy to measure, reliable and reproducible<sup>4</sup>.

## Patients and Methods

### *Study design & settings*

Current study is a descriptive cross sectional study conducted in Echocardiography unit of Ibn-Alnafies Cardiac Center, Ibn-Albitar Cardiac Center & Baghdad Teaching Hospital in Baghdad city during the period from 1st of September, 2018 to 31st of March, 2019.

### *Study population*

Patients with teratology of Fallot after surgical repair during their follow up referred to Echocardiography unit were the study population.

### *Inclusion criteria*

TOF patients on post-operative repair regardless of age and gender.

### *Exclusion criteria*

1. Variant of TOF (pulmonary atresia with ventricular septal defects).
2. Presence of significant residual abnormalities (ventricular septal defect, valvular or peripheral pulmonary stenosis & Tricuspid regurg).

### *Sampling of patients:-*

A convenient sample size of 50 patients with teratology of Fallot after surgical repair referred to Echocardiography unit was selected. The controls were healthy individuals were selected from relatives of patients.

### *Data Collection*

The data was collected by researcher from the patients directly or from their relatives and filled in a prepared questionnaire. The questionnaire was designed by the supervisor and researcher. The questionnaire included the followings.

1. Demographic characteristics of TOF patients: Age and gender.
2. Echocardiography characteristics of TOF patients postoperatively: Right ventricular status, right ventricle-fractional area change, tricuspid annular plane systolic excursion and pulmonary regurgitation.
3. Tissue Doppler Echocardiography findings of TOF patients postoperatively: Myocardial performance index, Systolic velocity (S') and isovolumic acceleration (IVA).
4. Outcome of TOF patients postoperatively period.

## Results

Echocardiography of TOF patients revealed that 44% of them had right ventricular dilation. Mean right ventricle fractional area change was  $36.9 \pm 4.4$  %; 28% of TOF patients had abnormal RV-FAC. Mean tricuspid annular plane systolic excursion was  $19.2 \pm 4.4$  mm; 22% of TOF patients had abnormal TAPSE. Mean myocardial performance index was  $0.46 \pm 0.07$ ; 18% of TOF patients had abnormal MPI. Mean global RV systolic function was  $11.1 \pm 2.7$  cm/s; 22% of TOF patients had abnormal . Mean myocardial acceleration during isovolumic contraction was  $2 \pm 0.8$  m/s<sup>2</sup>; 38% of TOF patients had abnormal IVA. All these findings were shown in table 1.

**Table 1: Echocardiography characteristics of TOF patients postoperatively.**

Variable	No.	%
<b>Right ventricle</b>		
Normal	28	56.0
Dilated	22	44.0
Total	50	100.0
<b>RV-FAC Mean<math>\pm</math>SD (<math>36.9 \pm 4.4</math> %)</b>		
Abnormal	14	28.0
Normal	36	72.0
Total	50	100.0
<b>TAPSE Mean<math>\pm</math>SD (<math>19.2 \pm 4.4</math> mm)</b>		
Abnormal	11	22.0
Normal	39	78.0
Total	50	100.0
<b>Mean<math>\pm</math>SD (<math>11.1 \pm 2.7</math> cm/s)</b>		
Abnormal	11	22.0
Normal	39	78.0
Total	50	100.0
<b>IVA Mean<math>\pm</math>SD (<math>2 \pm 0.8</math> m/s<sup>2</sup>)</b>		
Abnormal	19	38.0
Normal	31	62.0
Total	50	100.0
<b>MPI Mean<math>\pm</math>SD (<math>0.46 \pm 0.07</math>)</b>		
Abnormal	9	18.0
Normal	41	82.0
Total	50	100.0

Pulmonary regurgitation of TOF patients postoperatively was classified into mild (54%), moderate (30%) and severe (16%). Mean time of postoperative study for TOF patients was  $4.7 \pm 4.2$

years; 14% of them less than one year study, 54% from 1-5 years study and 32% of them over 5 years study. All these findings were shown in table 2.

**Table 2: Outcome of TOF patients postoperatively.**

Variable	No.	%
<b>Pulmonary regurgitation</b>		
Mild	27	54.0
Moderate	15	30.0
Severe	8	16.0
Total	50	100.0
<b>Time of postoperative study Mean±SD (4.7±4.2 years)</b>		
<1 year	7	14.0
1-5 years	27	54.0
>5 years	16	32.0
Total	50	100.0

No significant differences were observed between TOF patients and controls regarding age (p=0.4). There was a significant association between TOF

patients and male gender (p=0.04). All these findings were shown in table 3.

**Table 3: Distribution of demographic characteristics according to study groups.**

Variable	TOF		Controls		P
	No.	%	No.	%	
<b>Age</b>					0.4* NS
<10 years	31	62.0	25	50.0	
10-17 years	12	24.0	15	30.0	
18 years	7	14.0	10	20.0	
<b>Gender</b>					0.04* S
Male	30	60.0	20	40.0	
Female	20	40.0	30	60.0	

*Chi-square test, S=Significant, NS=Not significant.*

There was a significant association between ventricular dilation detected by echocardiography and TOF patients postoperatively in comparison to healthy

controls (p<0.001). All these findings were shown in table 4.

**Table 4: Distribution of right ventricle status according to study groups.**

Variable	TOF		Controls		P
	No.	%	No.	%	
<b>Right ventricle</b>					<0.001* <sup>S</sup>
Normal	28	56.0	50	100.0	
Dilated	22	44.0	0	-	

*\*Chi-square test, S=Significant.*

There was a significantly lower RV-FAC for TOF patients postoperatively in comparison to controls (p<0.001). Mean TAPSE of TOF patients postoperatively was significantly lower than TAPSE mean of controls (p<0.001). Mean MPI of TOF patients postoperatively was significantly higher than MPI mean of controls (p<0.001). The mean of TOF

patients postoperatively was significantly lower than mean of controls (p<0.001). There was a significantly lower mean of IVA for TOF patients postoperatively in comparison to controls. Mean heart rate of TOF patients postoperatively was significantly higher than heart rate of controls (p=0.01). All these findings were shown in table 5.

**Table 5: Distribution of echocardiography and tissue Doppler means according to study groups.**

Variable	TOF	Controls	P
	Mean±SD	Mean±SD	
RV-FAC (%)	36.9±4.4	43.1±4.6	<0.001* <sup>S</sup>
TAPSE (mm)	19.2±4.4	22.5±2.8	<0.001* <sup>S</sup>
MPI	0.46±0.07	0.35±0.06	<0.001* <sup>S</sup>
(cm/s)	11.1±2.7	13.7±2.5	<0.001* <sup>S</sup>
IVA (m/s <sup>2</sup> )	2±0.8	3.1±0.7	<0.001* <sup>S</sup>

\*Independent sample t-test, S=Significant.

## Discussion

Postoperative assessment of teratology of Fallot by Echocardiographic Doppler study is helpful in obtaining non-invasive hemodynamic picture assisting physicians in clinical decision. Additionally, Echocardiographic Doppler study also helps in estimating the severity of postoperative complications following teratology of Fallot surgery <sup>1</sup>.

Present study showed a significant association between TOF patients and male gender (p=0.04). This finding is similar to results of Sarikouch et al<sup>35</sup> study in Germany which reported gender differences in late repair of TOF. Our study also showed a significant association between ventricular dilation detected by echocardiography and TOF patients postoperatively in comparison to healthy controls (p<0.001). Consistently, O'Meagher et al<sup>8</sup> study in Australia revealed that TOF patients with free pulmonary regurgitation had right ventricular dilation after repair of TOF. This right ventricular dilation might lead to poor outcomes like exercise intolerance, arrhythmia and sudden cardiac death <sup>7,8</sup>.

In present study, mean right ventricle fractional area change of patients with TOF after surgery was significantly lower than that for healthy controls (p<0.001). Li et al<sup>9</sup> study in China reported that after TOF surgery, the short term improvement in right ventricle was observed in children but not in adults and the status of preoperative ventricle is a predictor for postoperative ventricular status. Our study showed that mean TAPSE of TOF patients postoperatively was significantly lower than TAPSE mean of controls (p<0.001). This finding is consistent with results of Pietrzak and Werner study in Spain which found that TAPSE of patients after TOF repair is obviously decreased especially if accompanied by right ventricular dilation <sup>10</sup>. The current study also revealed that mean MPI of TOF patients postoperatively was

significantly higher than MPI mean of controls (p<0.001). In India, a study conducted by Nair et al<sup>11</sup> on 173 TOF patients after surgical repair by tissue Doppler imaging, found that myocardial performance index of patients was higher among asymptomatic patients and this was indicative for right ventricular dysfunction.

Current study showed that tricuspid peak systolic velocity ( ) mean of TOF patients postoperatively was significantly lower than mean of controls (p<0.001). Similarly, Haber et al<sup>12</sup> study in Austria stated that Doppler mean of patients after TOF repair if decreased; it would be predictive for right ventricular impairment. Our study found that mean isovolumic acceleration (IVA) of TOF patients after surgery was significantly lower than that of controls (p<0.001). This finding coincides with reports of Villafañe et al<sup>13</sup> study in USA which documented that lower means of IVA is helpful for early detection of right ventricular dysfunction.

Our study showed that pulmonary regurgitation in TOF patients after surgery was mild in 54% of them, moderate in 30% of them and severe in 16% of them. These findings are in agreement with results of Ammash et al<sup>14</sup> study in USA which revealed that severe pulmonary regurgitation was detected in 15% of TOF patients after surgery. In current study, Echocardiography measures like RV-FAC and TAPSE were significantly decreased among TOF patients with severe pulmonary regurgitation, while mean MPI of TOF patients was increased with advanced severity of pulmonary regurgitation. These findings are similar to results of Senthilnathan et al<sup>15</sup> study in Canada which stated that in TOF patients after repair, Echocardiography parameters such as RV-FAC, TAPSE and MPI are used as tools for diagnosis of severity of pulmonary regurgitation. Our study revealed that mean of TOF patients was significantly declined among patients with severe pulmonary regurgitation (p=0.001).



Consistently, Ibrahim study in Egypt found that mean velocity of TOF patients after repair was significantly lower than that of healthy controls<sup>16</sup>. Indeed, our study found that IVA mean of TOF patients postoperatively was significantly decreased among patients with severe pulmonary regurgitation ( $p < 0.001$ ). Similarly, Frigiola et al<sup>17</sup> study in UK determined the IVA as an earlier marker of severe pulmonary regurgitation for patients with TOF after surgery. Another study conducted in France by Khraiche and Moussa, revealed that IVA is a significant predictor for severity of pulmonary regurgitation after surgical repair of patients with TOF<sup>18</sup>. Tigen et al<sup>19</sup> study in Turkey stated that right ventricular IVA assessment by postoperative tissue Doppler is useful in following up right ventricle function regardless of atrial rhythm.

Our study found that the IVA had acceptable validity findings (81.8% sensitivity and 96.4% specificity) in comparison to other echocardiography measurements. These findings are consistent with results of Carminati et al<sup>1</sup> study in Italy which stated that assessment of TOF patients with IVA measured by Doppler had the higher validity findings in detection of right ventricular dysfunction. Koestenberger study in Austria reported that main benefit of using IVA is that it is accompanied with somewhat load-independent measure of right ventricle activity<sup>20</sup>. However, the main obstacle associated with use of IVA is fact that it is sensitive to heart rate and accompanied with increased risk of interobserver variability<sup>20</sup>. In India, Bharathi et al<sup>21</sup> carried out single-centered prospective observational case-control study on 32 patients pulmonary hypertension and found that isovolumic acceleration higher validity findings (sensitivity 70.4% and specificity 81.1%) in early detection of right ventricular dilation<sup>21</sup>. The guidelines of American Society of Echocardiography by Rudski et al<sup>4</sup> reported that although the importance of echocardiography in assessing right ventricle, but its benefit is qualitative because of great obstacles in assessment of right ventricular volumes due to unusual shapes. However, they reported that isovolumic acceleration assessment by echocardiographic Doppler study is fundamental is assessment of right ventricular function and pulmonary regurgitation for patients with TOF after surgical repair<sup>4</sup>.

## Conclusions

➤ The isovolumic acceleration assessed by Doppler echocardiography is valid tool in assessment of right ventricle for patients with teratology of Fallot after surgical repair.

➤ The velocity measures of Doppler echocardiography such as isovolumic acceleration and systolic velocity are best measures for severity of pulmonary regurgitation for patients with teratology of Fallot after surgical repair.

➤ Echocardiography measures like right ventricle fractional area change, tricuspid annular plane systolic excursion and myocardial performance index are helpful in assessing patients with teratology of Fallot after surgical repair.

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