International Journal of Contemporary Pediatrics
Kabir R et al. Int J Contemp Pediatr. 2022 Apr;9(4):314-318
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20220754

Original Research Article

Echocardiography assessment of right ventricular dysfunction during postoperative period following total correction of tetralogy of Fallot

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Received: 28 December 2021
Accepted: 15 February 2022

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ABSTRACT

Background: Despite major advances in intracardiac surgery since Lillehei and Varco reported the first tetralogy of Fallot (TOF) repair by an open-heart procedure in 1954, right ventricular (RV) dysfunction remains an important clinical problem during the postoperative periods following TOF correction.
Methods: This was a cross-sectional study conducted at the department of paediatric cardiology in Bangabandhu Sheikh Mujib medical university (BSMMU), Shahbag, Dhaka in collaboration with national heart foundation hospital and research institute (NHFH and RI) Mirpur, Dhaka, Bangladesh during the period from July 2018 to June 2019. Ethical consideration was approved by the proper concerns. The final sample size was 49. Data analysis was carried out by using the social science (SPSS) version 23.0 windows software.
Results: The study was conducted on 49 patients, comprising 30 males and 19 females' children, and their mean age was 75.38±52.22 months. RV dysfunction global was 63.3% at 24 hours of operation, significantly reduced 49% and 32.7% at 7th and 30th POD respectively. Chi-square test was done where $p<0.05$. Global dysfunction was 13 (54.2) in ≤5 years, 18 (72.0) in >5 years aged patients.
Conclusions: RV dysfunction was more frequent after 24 hours of the postoperative period then it gradually decreases over a period of time

Keywords: Cyanosis, TOF, Post-operative, Post-operative RV dysfunction

INTRODUCTION

Tetralogy of Fallot (TOF) has quintessential features resulting from anterocephalad displacement of the outlet septum resulting in the large anterior maligned ventricular septal defect (VSD), RV outflow tract obstruction (RVOTO), RV hypertrophy and a rightward positioned overriding of the aorta. Multi-level pulmonary stenosis with its most extreme expression is being pulmonary arterial hypoplasia and/or pulmonary atresia.[1] Several studies indicate that the prevalence of TOF ranges from 2.8 to 3.9 per 10 000 live births, with males and females are being affected equally and 3.5 to 10% of the patients with CHD have TOF.[2,16] observed that preoperative clinical factors such as repair at a late age, low preoperative arterial oxygen saturation, cyanosis, cyanotic spell, are associated with RV dysfunction. RV dysfunction also has been attributed to many factors such as anatomical defects with small main pulmonary artery annulus, severe hypoplasia or absent right or left pulmonary artery, ventriculotomy, RV outflow patch, myocardial hypoxia during cardiopulmonary bypass, or

ARDS.[3] RV dysfunction is an important determinant of poor clinical status in repaired TOF patients. Literature has shown, its prevalence ranges from 28% to 63%.[4,7] As with other types of congenital and acquired disease, diagnostic information in patients with repaired TOF can be obtained using a variety of diagnostic tools Echocardiography allows the evaluation of many of the anatomic and hemodynamic abnormalities in patients with repaired TOF. This modality is relatively inexpensive, widely available, not associated with exposure to harmful ionizing radiation, and portable. Therefore, echocardiography is ideally suitable for longitudinal follow-up in this group of patients. Its quantitative parameters used to evaluate the RV function are distinguished in geometrical and non-geometrical parameters: the first is based on bi-dimensional and three-dimensional measurements of RV volumes, the second relies on various technologies including M-mode, myocardial Doppler imaging, tissue Doppler imaging (TDI), and 2D strain.[5] Congenital heart disease (CHD) are structural abnormalities of the heart or intrathoracic great vessels occurring during fetal development.[6]

Myocardial performance index (MPI) is a non-geometrical index that could be used to assess RV global function. According to MPI >0.24±0.04 irrespective of age indicates global RV dysfunction.[8,10] Considered the normal value of MPI less than 0.24±0.04 irrespective of age. MPI was affected by load and heart rate and disregard's segmental function. However, as a simple non-geometric echocardiographic parameter, MPI was calculated in several studies to assess RV function after the surgical repair of TOF. MPI was potentially a simple, reproducible, and readily available indicator of ventricular dysfunction.[9] The current study demonstrated that preoperative and at 24 hours of operation, mean MPI was 0.28±0.01 and 0.39±0.11 respectively (page 36, tab 4.6). MPI significantly increased in comparison to the pre and 24-hour postoperative data. But it gradually decreased in the 7th and 30th POD. Although at 30th days MPI was significantly higher comparing preoperative value.[11]

In this study, RV dysfunction was assessed in the post-operative period following total correction of TOF correction by echocardiography.

Objectives

General objective

The general objective of the study was to assess RV dysfunction in the postoperative period following total correction of TOF.

Specific objectives

The specific objectives of the study was to assess global RV function of preoperative at 24 hours, 7th and30th postoperative days following total correction of TOF by echocardiography.

METHODS

This was a cross-sectional study conducted at the department of paediatric cardiology in Bangabandhu Sheikh Mujib medical university (BSMMU), Shahbag, Dhaka in collaboration with national heart foundation hospital and research institute (NHFH and RI) Mirpur, Dhaka, Bangladesh during the period from July 2018 to June 2019. Ethical consideration was approved by the institutional ethical committee of BSMMU and it was obtained before the commencement of this study. Sampling techniques were consecutive sampling, the estimated sample size is 48 patients, dropped out at follow-up might happen during the study period. That's why we took the sample size 10% more. So, the sample size was 56. During the study period 5 patients were lost during the follow-up and 2 patients had poor echo windows. So, the final sample size was 49 which achieve 80% power to detect a difference of 0.20 using a two-sided exact test with a significance level (alpha) of 0.05. Statistical analysis was planned and reviewed by the investigators and guide. After editing, data analysis was carried out by using SPSS version 23.0. A $p<0.05$ was considered significant.

Inclusion criteria

Patients with age 6 months to 18 years, TOF with confluent pulmonary arteries (McGoon ratio ≥1.5), good biventricular function were included in the study.

Exclusion criteria

Patients with presence of pulmonary valve atresia with ventricular septal defect, double outlet right ventricle (DORV), TOF associated with other complex congenital heart diseases and TOF with coronary abnormalities, patients with a prior systemic-pulmonary artery shunt and previous history of any cardiac surgery and severely ill with other co-morbid conditions were excluded in the study.

Operational definition: RV dysfunction (Global)

MPI>0.24±0.04 irrespective of age.[8]

RESULTS

In the given period, a total of 60 TOF patients were admitted. among them 4 patients excluded for not meeting inclusion criteria, So, a total of 56 patients were enrolled in the study. During the postoperative period, 2 patients had poor echo windows at 24 hours, 5 patients dropped out during follow-up at 30th days and no death during the study time. So final analysis was done 49 patients. Based on the operational definition of RV dysfunction define as global. Frequency and percentages

of RV dysfunction were calculated and analysis was done.

Table 1: Demographic profile of the study subjects, (n=49).

Variables	Frequency	Percent (%)
Age (months)	75.38±52.22 (12-216)	
Gender [n (%)]		
Male	30	61.22
Female	19	38.78
BSA (kg/m²)	0.61±0.23 (0.36-1.50)	

Table 1 showing: Results were expressed as mean ± SD, frequency and percentage. Demographic profile of the study the mean age of the study subjects was 75.38±52.22 months. Males and females were 30 (61.22%), 19 (38.78%) respectively. The mean BSA was 0.61±0.23.

Table 2: Distribution of the study subjects according to CT angiogram data, (n=49).

Variables	Mean ± SD	Min-max
McGoon ratio	2.04±0.21	1.70-2.80
Nakata index	189.57±13.14	180-220
PVA	10.30±1.90	8.00-14.00
MPA	10.30±1.90	8.00-14.00
RPA	10.17±1.84	8.00-14.00
LPA	10.04±1.74	8.00-11.00

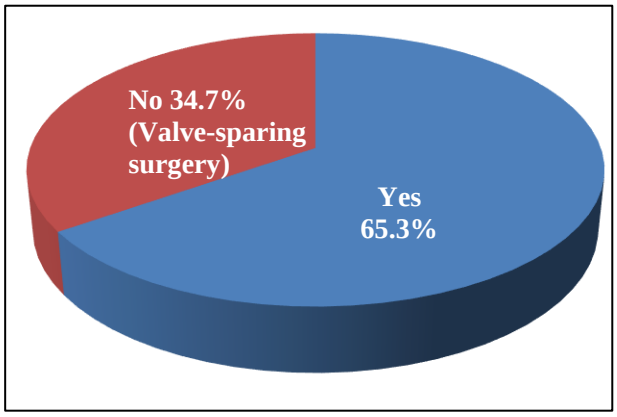

Figure 1: Transannular patch insertion.

Figure 1 found TAP was done in 65.3% of patients, whereas 34.7% had valve-sparing surgery without the use of the patch.

Table 2 showing: Results were expressed as mean ± SD, CT angiogram findings of the study subjects showed that mean McGoon ratio was 2.04±0.21, mean Nakata index was 189.57±13.14, mean PVA was 10.30±1.90, mean MPA was 10.30±1.90, mean RPA was 10.17±1.84 and mean LPA was 10.04±1.74.

Table 3: Post-operative recovery factors of the study subjects, (n=49).

Variables	Mean ± SD	Min-max
Ventilation (hours)	43.45±26.67	2-108
Drain time (hours)	52.63±24.16	24-120
Inotrope duration (hours)	57.06±25.80	24-144
ICU stay (days)	3.24±1.92	1-9

Table 3 showing: Results were expressed as mean ± SD, Postoperative factors of the study subjects showed that mean ventilation time was 43.45±26.67 hours, mean drain time was 52.63±24.16 hours, mean inotrope duration was 57.06±25.80 hours, mean ICU stay was 3.24±1.92 days.

Table 4 viewing: Results were expressed as mean ± SD. Paired t test was done as test of significance, p<0.05 was considered as significance. P value (1): Preoperative vs after 24 hours p value (2): Preoperative vs at 7th day p value (3): Preoperative vs at 30th day. Pre and postoperative RV function (global) based on the MPI of the study subjects showed that MPI was significantly increased at 24 hours,7th and 30th postoperative days comparing to preoperative value.

McNemar test was done as test of significance, p<0.05 was considered as significance, p (1): At 24 hour's vs at 7th day, p (1): At 24 hour's vs at 30th day.

Postoperative RV dysfunction rate of the study subjects showed that RV dysfunction (global) was 63.3% after 24 hours of operation, significantly reduced to 49.0% at 7th POD and 32.7% at 30th POD.

Table 4: Pre and postoperative RV dysfunction of the study subjects, (n=49).

RV function (global)	Pre-operative	Post-operative					
		After 24 hours	P value (1)	At 7th day	P value (2)	At 30th day	P value (3)
Myocardial performance index (MPI)	0.27±0.08	0.39±0.11	<0.001	0.35±0.08	<0.001	0.31±0.05	<0.001

Table 5: Post-operative RV dysfunction rate of the study subjects, (n=49).

RV dysfunction	Post-operative				
	After 24 hours	At 7th day	P value (1)	At 30th day	P value (2)
Global	31 (63.3%)	24 (49.0%)	<0.001	16 (32.7%)	<0.001

Table 6: Post-operative RV dysfunction according to the age of the study subjects, (n=49).

Variables	Age (months)		P value
	≤ 60 (≤5 years), (n=24)	> 60 (> 5 years), (n=25)	
Global dysfunction (MPI>0.28)	13 (54.2)	18 (72.0)	0.196

Chi-Square test was done as test of significance, p<0.05 was considered as significance global dysfunction was 13 (54.2) in ≤5 years aged patients and 18 (72.0) in >5 years aged patients. There was no significant difference in global dysfunction between two age groups.

DISCUSSION

The high incidence in our study might be due to the delayed presentation, chronic hypoxia and in most cases, a transannular patch was used. Due to this late presentation, RV is severely hypertrophied and at increased risk of developing both systolic and diastolic dysfunctions in the postoperative period. The identification of RV dysfunction after TOF repair is of vital importance because the early identification of individuals at greatest risk and timely intervention will most likely improve clinical outcomes. After TOF repair, prolonged postoperative course due to impairment of ventricular function particularly of the right ventricle has not been studied in detail in our country, but as Bangladesh is experiencing an epidemiological transition from communicable to non-communicable diseases, cardiovascular diseases are supposed to be one of the major causes of mortality and morbidity.[12]

RV dysfunction related to age has been investigated by some authors reported that patients undergoing surgery at later age had restrictive RV physiology more frequently than earlier. It is inversely related to age at repair. In that study, the patients repaired in early infancy had evidence of 28% abnormal RV diastolic function at mid-term follow-up. In this study, RV dysfunction was significantly more in above 60-month group comparing to below 60 months' group. RV dysfunction is a frequent and important medical problem during the postoperative period following TOF correction. In the developing world, it is more frequent than the developed country. Intracardiac repair (ICR) is the definitive management of TOF. RV dysfunction is commonly present even after satisfactory ICR. Its etiology remains unclear. The acute change from a pressure-loaded to a volume-loaded RV, in addition to the right ventriculotomy, can adversely affect the performance of the RV in the immediate postoperative period.[14] The present study demonstrated that RV dysfunction (global) was 63.3% after 24 hours of operation, significantly reduced to 49% at 7th POD and 32.7% at 30th POD (page 41, tab 4.11). After complete surgical repair of TOF, the RV dysfunction was detected in 54.16% at 24 hours of operation and at 4weeks 38.46% in the study.[14]

The current study demonstrated that CT angiogram findings of the study subjects showed that mean ± SD,

CT angiogram findings of the study subjects showed that mean McGoon ratio was 2.04±0.21, mean Nakata index was 189.57±13.14, mean PVA was 10.30±1.90, mean MPA was 10.30±1.90, mean RPA was 10.17±1.84 and mean LPA was 10.04±1.74. TAP was done in 65.3% of patients, whereas 34.7% had valve-sparing surgery without the use of the patch. Post-operative factors of the study subjects showed that results were expressed as mean ± SD, postoperative factors of the study subjects showed that mean ventilation time was 43.45±26.67 hours, mean drain time was 52.63±24.16 hours, mean inotrope duration was 57.06±25.80 hours, and mean ICU stay was 3.24±1.92 days. RV diastolic dysfunction is demonstrable by Doppler echocardiography in the first week following surgery for TOF and tends to be worse with TAP.[17] Chronic pulmonary regurgitation has been associated with RV dysfunction, exercise intolerance and ventricular dysrhythmias.[15] Observed that 25 patients with a mean ± SD age of 14.1±4.4 years who underwent primary repair of TOF, the MPI (1.08±0.35 vs. 0.58±0.11, p=0.0001) was higher than the matched control group. They found that IVCT and IVRT increased due to delayed systolic activation and delayed RV relaxation, respectively.

Limitations

This was a single-center study and patient volume was small.

CONCLUSION

RV dysfunction was more frequent after 24 hours of the postoperative period then it gradually decreases over a period of time.

Recommendations

Future studies with larger patient volumes are warranted to assess RV dysfunction in the postoperative period following TOF correction; further in-depth and multi-center study is required in our country in this field; compare with cardiac MRI is necessary and long-term follow-up is required.

Funding: No funding sources
Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Kabir R, Hussain MZ, Islam MT, Chowdhury NAH, Karim T, Rahman A et al. Echocardiography assessment of right ventricular dysfunction during postoperative period following total correction of tetralogy of Fallot. Int J Contemp Pediatr 2022;9:314-8.