Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 32s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Echocardiographic Evaluation of Right Ventricular Hypertrophy Regression After Total Correction of Tetralogy of Fallot in Pediatric Patients

Dr. Md. Alauddin[1*], Dr. Mohammad Samir Azam Sunny[2], Dr. Khan Mohammad Amanur Rahman[3], Dr. Nawrin Hossain[4], Dr. Marina Ahmed[5], Prof. Dr. Md. Mostafizur Rahman[6]

[1]Associate Professor, Department of Cardiac Surgery, Bangladesh Medical University, Dhaka, Bangladesh

[2]Associate Professor, Department of Cardiac surgery, Bangladesh Medical University, Dhaka, Bangladesh

[3]Associate Professor, Department of Cardiac surgery, Bangladesh Medical University, Dhaka, Bangladesh

[4]Medical Officer, Department of Cardiac Surgery, Dhaka Medical College Hospital, Dhaka, Bangladesh

[5]Registrar, Department of Cardiac Surgery, National Heart Foundation Hospital & Research Institute (NHFH & RI), Dhaka, Bangladesh

[6]Professor, Department of Cardiac Surgery, Bangladesh Medical University, Dhaka, Bangladesh

***Corresponding Author**

Dr. Md. Alauddin,

Associate Professor, Department of Cardiac Surgery, Bangladesh Medical University, Dhaka, Bangladesh

Cite this paper as: Dr. Md. Alauddin, Dr. Mohammad Samir Azam Sunny, Dr. Khan Mohammad Amanur Rahman, Dr. Nawrin Hossain, Dr. Marina Ahmed, Prof. Dr. Md. Mostafizur Rahman, (2025) Echocardiographic Evaluation of Right Ventricular Hypertrophy Regression After Total Correction of Tetralogy of Fallot in Pediatric Patients. *Journal of Neonatal Surgery*, 14 (32s), 6711-6715.

ABSTRACT

Background: Tetralogy of Fallot is a congenital heart defect characterized by right ventricular hypertrophy and other anatomical abnormalities that significantly impact postoperative cardiac function. The purpose of this study is to assess the regression of right ventricular hypertrophy following total surgical correction of TOF in pediatric patients using echocardiographic assessment.

Aim of the study: The aim of the study was to evaluate the regression of right ventricular hypertrophy following total surgical correction of Tetralogy of Fallot in pediatric patients using serial echocardiographic assessment.

Methods: This descriptive cross-sectional study was conducted at the Department of Cardiac Surgery, Bangladesh Medical University, Dhaka, from January 2024 to January 2025. Thirty pediatric TOF patients undergoing total correction were evaluated with serial echocardiography at baseline, 7th POD, 1 month, and 3 months to assess RV wall thickness, diameter, and systolic pressure. Paired t-tests analyzed changes using SPSS v26 ($p < 0.05$).

Results: Among 30 pediatric TOF patients (mean age 5.53 ± 2.95 years; 60% male), preoperative RV hypertrophy (mean wall thickness 7.63 mm) and hypoxemia ($SpO_2 < 85\%$ in 56.7%) were common. By 3 months post-surgery, RV wall thickness decreased by 18.3% (to 6.23 mm), RV diameter by 12.4% (to 21.2 mm), and RV systolic pressure by 28.2% (to 34.8 mmHg; all $p < 0.0001$). The greatest RV regression (24.1%) occurred in the 1–3 year age group, highlighting better remodeling with earlier repair.

Conclusion: Total correction of Tetralogy of Fallot in pediatric patients leads to significant right ventricular hypertrophic regression, especially when performed at a younger age.

Keywords: *Echocardiography, Right Ventricular Hypertrophy, Tetralogy of Fallot*

INTRODUCTION

Tetralogy of Fallot (TOF) is defined by four hallmark anatomical defects arising from anterocephalad displacement of the outlet septum: a large, anteriorly malaligned ventricular septal defect (VSD), right ventricular outflow tract obstruction (RVOTO), right ventricular hypertrophy, and an overriding aorta [1]. The prevalence of TOF is reported to range between 2.8 and 3.9 per 10,000 live births, affecting males and females equally. It accounts for approximately 3.5% to 10% of all congenital heart disease (CHD) cases according to various studies [2,3].

Right ventricular (RV) dysfunction plays a critical role in determining adverse clinical outcomes in patients who have undergone repair for Tetralogy of Fallot (TOF) [4,5]. Transthoracic echocardiography is the primary tool used during

postoperative follow-up, with particular emphasis on evaluating RV systolic function, as impairment in this parameter is closely linked to poorer prognosis [6]. Even after successful surgical correction, residual defects and chronic pressure or volume overload can contribute to ongoing RV remodeling, highlighting the importance of regular and detailed monitoring to detect early signs of dysfunction [7].

Echocardiography provides an effective means of assessing both anatomical and hemodynamic abnormalities in patients with repaired Tetralogy of Fallot (TOF). Its affordability, widespread availability, portability, and lack of ionizing radiation make it particularly suitable for repeated evaluations, especially in children [8]. Among the echocardiographic parameters, right ventricular global longitudinal strain (RV-GLS) has emerged as a promising metric, demonstrating the strongest correlation with cardiac MRI in evaluating RV systolic function[9]. Consequently, echocardiography continues to serve as the primary modality for ongoing postoperative monitoring in this patient group.

Multiple pathological and clinicopathologic studies have supported the benefits of early complete surgical repair of Tetralogy of Fallot (TOF) over a staged approach, demonstrating that delayed definitive repair is associated with greater degrees of myocardial hypertrophy and fibrosis [10-15]. However, the specific impact of early total correction on the extent of right ventricular (RV) hypertrophy remains underexplored, despite evidence that RV hypertrophy is not congenital but develops postnatally [16]. This underscores the significance of timely surgical intervention and ongoing follow-up to assess the potential for reverse remodeling of the hypertrophied RV.

Despite advances in surgical techniques and postoperative imaging, limited data exist on the temporal pattern and extent of right ventricular hypertrophic regression following total correction of TOF, particularly in pediatric populations. Most studies have focused on RV function or dilation, while few have quantitatively assessed the remodeling of RV wall thickness over time using serial echocardiography. The purpose of the study is to assess the regression of right ventricular hypertrophy following total surgical correction of Tetralogy of Fallot in pediatric patients using serial echocardiographic assessment.

Objective

- To evaluate the regression of right ventricular hypertrophy following total surgical correction of Tetralogy of Fallot in pediatric patients using serial echocardiographic assessment.

METHODOLOGY & MATERIALS

This descriptive cross-sectional study was conducted at the Department of Cardiac Surgery, Bangladesh Medical University, Dhaka, from January 2024 to January 2025. A total of 30 pediatric patients diagnosed with Tetralogy of Fallot (TOF) were included. Patients were selected based on specific inclusion and exclusion criteria to evaluate the regression of right ventricular hypertrophy following total surgical correction, using serial echocardiographic assessments.

Inclusion Criteria:

- Diagnosed with Tetralogy of Fallot (TOF)
- Underwent total corrective cardiac surgery during the study period
- Available echocardiographic follow-up at preoperative baseline, 7th postoperative day (POD), 1 month, and 3 months

Exclusion Criteria:

- History of previous cardiac surgery
- Associated complex congenital heart defects (e.g., pulmonary atresia, double outlet right ventricle)
- Significant non-cardiac comorbidities affecting cardiac function (e.g., severe pulmonary disease, renal failure)
- Incomplete follow-up or missing echocardiographic data

All enrolled patients underwent standardized transthoracic echocardiographic evaluations at four defined time points: preoperatively, on the 7th POD, at 1 month, and at 3 months postoperatively. Key parameters assessed included right ventricular (RV) wall thickness, RV diameter, and right ventricular systolic pressure (RVSP), measured using color Doppler imaging. All echocardiographic measurements were performed by experienced echocardiographers using a consistent imaging protocol and equipment. Demographic and clinical data were retrieved from hospital records. The primary outcome was the regression of RV wall thickness over 3 months, while secondary outcomes included changes in RV diameter and RVSP. Data were analyzed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean ± standard deviation (SD), and changes from baseline were reported as percentage reductions. Paired t-tests were used to compare preoperative and postoperative values, with $p < 0.05$ considered statistically significant.

RESULTS

Table 1: Demographic and Baseline Characteristics of the Study Population (n = 30)

Variable		Frequency (n)	Percentage (%)
Age (years)	1–3	8	26.7%
	>3–6	10	33.3%

	>6–9	7	23.3%
	>9–12	5	16.7%
	Mean ± SD	5.53 ± 2.95	
Sex	Male	18	60.0%
	Female	12	40.0%
Weight at Surgery (kg)	<7.0	8	26.7%
	7.0–10.0	15	50.0%
	>10.0	7	23.3%
	Mean ± SD	8.53 ± 1.94	
Preoperative SPO_2 (%)	<85%	17	56.7%
	≥85%	13	43.3%
	Mean ± SD	84.6 ± 2.97	
Preoperative RV Wall Thickness (mm)	< 7 mm	6	20.0%
	7 – 8 mm	14	46.7%
	> 8 mm	10	33.3%
	Mean ± SD	7.63 ± 0.72	

Table 1 presents the baseline demographic and clinical characteristics of the 30 pediatric patients who underwent total corrective surgery for Tetralogy of Fallot. The mean age at surgery was 5.53 ± 2.95 years, with the highest proportion of patients (33.3%) falling within the >3–6 year age group. A male predominance was observed (60%). Half of the children (50%) had a body weight between 7.0–10.0 kg at surgery, with a mean of 8.53 ± 1.94 kg. Preoperative oxygen saturation averaged 84.6 ± 2.97%, with 56.7% of the cohort exhibiting hypoxemia (SpO_2 <85%). RV wall thickness prior to surgery averaged 7.63 ± 0.72 mm, with 80% of patients showing RV hypertrophy (wall thickness ≥7 mm), reflecting the chronic pressure overload associated with uncorrected TOF.

Table 2: Serial Echocardiographic Changes in Right Ventricular Parameters After Total Correction of TOF (n = 30)

Parameter	Pre-op	7th POD	1 Month	3 Months	% Δ¹	p-value
RV Wall Thickness (mm)	7.63 ± 0.72	7.10 ± 0.65	6.67 ± 0.60	6.23 ± 0.55	–18.3%	<0.0001
RV Diameter (mm)	24.2 ± 3.1	23.5 ± 2.9	22.4 ± 2.6	21.2 ± 2.4	–12.4%	<0.0001
Right Ventricular Systolic Pressure (RVSP, mmHg)	48.5 ± 6.3	42.7 ± 5.8	38.9 ± 5.2	34.8 ± 4.7	–28.2%	<0.0001

Table 2 presents the serial echocardiographic measurements of right ventricular parameters following total correction of TOF. A consistent and statistically significant reduction was observed in all parameters across the 3-month follow-up. RV wall thickness decreased from 7.63 ± 0.72 mm preoperatively to 6.23 ± 0.55 mm at 3 months, representing an 18.3% regression ($p < 0.0001$). RV diameter declined from 24.2 ± 3.1 mm to 21.2 ± 2.4 mm (–12.4%, $p < 0.0001$). The most marked improvement was seen in RV systolic pressure, which dropped from 48.5 ± 6.3 mmHg to 34.8 ± 4.7 mmHg (–28.2%, $p < 0.0001$), indicating substantial unloading of the right ventricle post-surgery.

Table 3: Age-Stratified Regression of RV Wall Thickness from Preoperative to 3 Months Post-Repair (n = 30)

Age Group (years)	n	Pre-op RV Wall (mm)	3-Month RV Wall (mm)	Absolute Δ (mm)	% Regression¹	p-value
1–3	8	7.9 ± 0.7	6.0 ± 0.6	– 1.9	24.10%	<0.0001
> 3–6	10	7.6 ± 0.6	6.3 ± 0.5	– 1.3	17.10%	<0.0001
> 6–9	7	7.4 ± 0.8	6.4 ± 0.6	– 1.0	13.50%	0.009
> 9–12	5	7.3 ± 0.7	6.5 ± 0.5	– 0.8	11.00%	0.042

Table 3 outlines age-specific changes in RV wall thickness from preoperative baseline to 3 months postoperatively. The most substantial regression occurred in the 1–3 year group, with a mean reduction of 1.9 mm (24.1%, $p < 0.0001$). This trend declined with increasing age: 17.1% in >3–6 years, 13.5% in >6–9 years, and only 11.0% in the oldest group (>9–12 years, $p = 0.042$). These findings suggest that earlier surgical intervention leads to more pronounced reverse remodeling of the right ventricle.

DISCUSSION

Right ventricular hypertrophy and dysfunction are significant concerns in pediatric patients with Tetralogy of Fallot undergoing surgical repair. This study highlights the echocardiographic changes and regression of right ventricular

hypertrophy following total corrective surgery in children treated at a tertiary cardiac surgery center in Bangladesh. The findings underscore the dynamic nature of right ventricular remodeling post-surgery, with age at repair and preoperative RV status influencing recovery. The observed serial improvements in RV wall thickness, diameter, and systolic pressure emphasize the importance of early intervention and continuous echocardiographic monitoring to optimize clinical outcomes.

In the present study, the mean age of the pediatric cohort undergoing total correction of Tetralogy of Fallot was 5.53 ± 2.95 years, which is closely aligned with the findings of Raj *et al*. [17], who reported a median age of 6 years (range 1–12), reflecting a similar age of presentation for surgical intervention. A male predominance was observed in our population (60%), which is consistent with the sex distribution (male 26, female 24) described by Raj *et al*.[17], reaffirming the slightly higher incidence of TOF among males. The mean weight at surgery in our cohort was 8.53 ± 1.94 kg, comparable to the findings of Sarikouch *et al*.[18], who reported a median weight of 9.0 kg (IQR 7.5–11.2), suggesting a parallel nutritional and growth status among TOF patients prior to surgery. Preoperative oxygen saturation in our patients averaged 84.6 ± 2.97%, with 56.7% having saturation levels below 85%, which is consistent with the hypoxemic profiles reported by Sandeep *et al*.[19], highlighting the chronic cyanosis often seen in uncorrected TOF. The mean preoperative right ventricular (RV) wall thickness in our study was 7.63 ± 0.72 mm, with the majority (80%) having values ≥7 mm, supporting the observations of Seliem *et al*.[20], who documented significant RV hypertrophy in pediatric TOF cases. Overall, the baseline characteristics of our study population are well aligned with previous literature, validating the demographic and clinical profile typical of TOF patients undergoing corrective surgery in similar settings.

The serial echocardiographic assessment demonstrated a clear and statistically significant regression in right ventricular (RV) parameters over the 3-month postoperative period, reflecting favorable reverse remodeling following total correction of Tetralogy of Fallot. RV wall thickness decreased progressively from 7.63 ± 0.72 mm preoperatively to 6.23 ± 0.55 mm at 3 months, indicating an 18.3% reduction. RV diameter also showed a consistent decline from 24.2 ± 3.1 mm to 21.2 ± 2.4 mm (–12.4%), while right ventricular systolic pressure (RVSP) demonstrated the most pronounced change, falling from 48.5 ± 6.3 mmHg to 34.8 ± 4.7 mmHg (–28.2%) during the same period. These improvements were all statistically significant ($p < 0.0001$). The observed trends align with the findings of Mercer-Rosa *et al*.[21], who noted early postoperative RV dysfunction followed by gradual functional and structural recovery. The sharp reduction in RVSP and chamber dimensions further supports the efficacy of timely surgical correction in unloading the right ventricle and initiating early myocardial recovery.

The age-stratified analysis in this study demonstrates a clear inverse relationship between age at the time of surgery and the extent of postoperative right ventricular (RV) wall thickness regression. Children aged 1–3 years exhibited the most significant reduction (24.1%), while the oldest group (>9–12 years) showed only an 11.0% decrease. These findings align with those of Seliem *et al*.[20], who reported substantial RV hypertrophy regression primarily in patients undergoing early repair before 6 months of age. Similarly, Ganni *et al*.[22] noted that prolonged exposure to pressure overload in unrepaired TOF leads to more advanced and less reversible hypertrophy with age. This reinforces the importance of timely surgical correction to optimize RV remodeling and long-term cardiac outcomes in pediatric patients.

Limitations of the study

This study had some limitations:

- The study was conducted in a selected tertiary-level hospital.
- The sample was not randomly selected.
- The study's limited geographic scope may introduce sample bias, potentially affecting the broader applicability of the findings.

CONCLUSION

This study demonstrates that total surgical correction of Tetralogy of Fallot in pediatric patients leads to significant regression of right ventricular hypertrophy, as evidenced by serial echocardiographic assessments over a three-month postoperative period. The observed reductions in RV wall thickness, diameter, and systolic pressure highlight effective reverse remodeling following surgery. Importantly, earlier surgical intervention, particularly in children aged 1–3 years, was associated with greater degrees of RV hypertrophic regression, emphasizing the clinical advantage of timely repair in optimizing right ventricular recovery and potentially improving long-term cardiac function in this population.

REFERENCES

1. Anderson RH, Weinberg PM. The clinical anatomy of tetralogy of Fallot. Cardiology in the Young. 2005 Feb;15(S1):38-47.

2. Rezwan MS. Congenital heart diseases among the hospital live birth in Bangladesh: A retrospective study in a tertiary medical college hospital. In4th International Conference on Clinical & Experimental Cardiology April 2014 (pp. 14-16).
3. Bailliard F, Anderson RH. Tetralogy of fallot. Orphanet journal of rare diseases. 2009 Dec;4:1-0.
4. Gatzoulis MA, Clark AL, Cullen S, Newman CG, Redington AN. Right ventricular diastolic function 15 to 35 years after repair of tetralogy of Fallot: restrictive physiology predicts superior exercise performance. Circulation. 1995 Mar 15;91(6):1775-81.
5. Cullen S, Shore D, Redington A. Characterization of right ventricular diastolic performance after complete repair of tetralogy of Fallot: restrictive physiology predicts slow postoperative recovery. Circulation. 1995 Mar 15;91(6):1782-9.
6. Srivastava S, Salem Y, Chatterjee S, Helen Ko H, Lai WW, Parness IA, Nielsen JC, Lytrivi ID. Echocardiographic Myocardial Deformation Evaluation of Right Ventricular Function in Comparison with CMRI in Repaired Tetralogy of F allot: A Cross-Sectional and Longitudinal Validation Study. Echocardiography. 2013 Feb;30(2):196-202.
7. Lai WW, Gauvreau K, Rivera ES, Saleeb S, Powell AJ, Geva T. Accuracy of guideline recommendations for two-dimensional quantification of the right ventricle by echocardiography. The international journal of cardiovascular imaging. 2008 Oct;24:691-8.
8. Ishii M, Eto G, Tei C, Tsutsumi T, Hashino K, Sugahara Y, Himeno W, Muta H, Furui J, Akagi T, Fukiyama R. Quantitation of the global right ventricular function in children with normal heart and congenital heart disease: a right ventricular myocardial performance index. Pediatric cardiology. 2000 Sep;21:416-21.
9. Bernard Y, Morel M, Descotes-Genon V, Jehl J, Meneveau N, Schiele F. Value of speckle tracking for the assessment of right ventricular function in patients operated on for tetralogy of fallot. Comparison with magnetic resonance imaging. Echocardiography. 2014 Apr;31(4):474-82.
10. Deanfield J, McKenna W, Rowland E. Local abnormalities of right ventricular depolarization after repair of tetralogy of Fallot: a basis for ventricular arrhythmia. The American journal of cardiology. 1985 Feb 15;55(5):522-5.
11. Deanfield JE, Ho SY, Anderson RH, McKenna WJ, Allwork SP, Hallidie-Smith K. Late sudden death after repair of tetralogy of Fallot: a clinicopathologic study. Circulation. 1983 Mar;67(3):626-31.
12. Kirklin JW, Blackstone EH, Jonas RA, Shimazaki Y, Kirklin JK, Mayer Jr JE, Pacifico AD, Castaneda AR. Morphologic and surgical determinants of outcome events after repair of tetralogy of Fallot and pulmonary stenosis: a two-institution study. The Journal of thoracic and cardiovascular surgery. 1992 Apr 1;103(4):706-23.
13. Sullivan ID, Presbitero PA, Gooch VM, Aruta ER, Deanfield JE. Is ventricular arrhythmia in repaired tetralogy of Fallot an effect of operation or a consequence of the course of the disease? A prospective study. Heart. 1987 Jul 1;58(1):40-4.
14. Deanfield JE, McKenna WJ, Presbitero P, England D, Graham GR, Hallidie-Smith K. Ventricular arrhythmia in unrepaired and repaired tetralogy of Fallot. Relation to age, timing of repair, and haemodynamic status. Heart. 1984 Jul 1;52(1):77-81.
15. Jones M, Ferrans VJ. Myocardial degeneration in congenital heart disease: comparison of morphologic findings in young and old patients with congenital heart disease associated with muscular obstruction to right ventricular outflow. The American Journal of Cardiology. 1977 Jun 1;39(7):1051-63.
16. LEV M, RIMOLDI HJ, ROWLATT UF. The quantitative anatomy of cyanotic tetralogy of Fallot. Circulation. 1964 Oct;30(4):531-8.
17. Raj R, Puri GD, Jayant A, Thingnam SK, Singh RS, Rohit MK. Perioperative echocardiography-derived right ventricle function parameters and early outcomes after tetralogy of Fallot repair in mid-childhood: a single-center, prospective observational study. Echocardiography. 2016 Nov;33(11):1710-1717.
18. Sarikouch S, Boethig D, Peters B, Kropf S, Dubowy KO, Lange P, Kuehne T, Haverich A, Beerbaum P. Poorer right ventricular systolic function and exercise capacity in women after repair of tetralogy of fallot: a sex comparison of standard deviation scores based on sex-specific reference values in healthy control subjects. Circulation: Cardiovascular Imaging. 2013 Nov;6(6):924-33.
19. Sandeep B, Huang X, Xu F, Su P, Wang T, Sun X. Etiology of right ventricular restrictive physiology early after repair of tetralogy of Fallot in pediatric patients. J Cardiothorac Surg. 2019 May 2;14(1):84.
20. Seliem MA, Wu YT, Glenwright K. Relation between age at surgery and regression of right ventricular hypertrophy in tetralogy of Fallot. Pediatric Cardiology. 1995 Mar;16:53-5.
21. Mercer-Rosa L, Yang W, Kutty S, Rychik J, Fogel M, Goldmuntz E. Quantifying pulmonary regurgitation and right ventricular function in surgically repaired tetralogy of Fallot: a comparative analysis of echocardiography and magnetic resonance imaging. Circulation: Cardiovascular Imaging. 2012 Sep;5(5):637-43.
22. Ganni E, Ho SY, Reddy S, Therrien J, Kearney K, Roche SL, Dimopoulos K, Mertens LL, Bitterman Y, Friedberg MK, Saraf A. Tetralogy of Fallot across the lifespan: a focus on the right ventricle. CJC pediatric and congenital heart disease. 2023 Dec 1;2(6):283-300.