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Right Ventricle Diastolic Dysfunction in Tetralogy of Fallot Patients Affecting Surgical Outcome

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ABSTRACT

Objective: To compare the surgical outcome of Tetralogy of Fallot patients with and without right ventricular diastolic dysfunction after repair.

Study Design: Quasi-experimental study.

Place and Duration of Study: Department of Cardiology, National Institute of Cardiovascular Disease, Karachi Pakistan, from May to Oct 2021.

Methodology: Patients above 5 months of age, of either gender, undergoing surgery for Tetralogy of Fallot were enrolled. Patients were divided into two groups according to the Gatzoulis' criterion for right ventricular restriction i.e. Group-A had right ventricle with restriction, and Group-B had right ventricle without restriction. Velocities of E and A waves was recorded, and their ratio (E/A) was calculated. The outcome such as aortic cross clamp, cardiopulmonary bypass time, ventilation time, intensive care unit stay, drain time, and transannular patch was noted.

Results: Of 54 patients, restrictive physiology patients had significantly higher mean for aortic cross-clamp (*p*-value 0.004, 95%CI 3.54 - 17.35), ventilation time (*p*-value<0.001, 95% CI 20.03-31.22), intensive care unit stay (*p*-value 0.014, 95% CI 0.19 - 1.65), drain time (*p*-value<0.001, 95% CI 105.29 - 31.21), and duration of inotropes (*p*-value<0.001, 95% CI 29.09 - 51.79). Moreover, transannular patch was significantly higher among patients with restrictive physiology as compared to the patients without non-restrictive physiology, i.e., 23(85.2%) vs. 8(29.6%) (*p*-value<0.001).

Conclusion: A considerable difference was observed in the surgical outcome of Tetralogy of Fallot patients with and without right ventricular diastolic dysfunction after repair.

Keywords: Repair, Right ventricular diastolic dysfunction, Tetralogy of fallot.

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INTRODUCTION

Tetralogy of Fallot (TOF) has been the most frequent cyanotic cardiac ailment in children who have survved beyond the neonatal period and require treatment within the first year of life.[1] Significant advances in anesthetic, operative, and postoperative management have been the stimulus for early primary repair of TOF.[2] Patients usually have good long-term survival and high quality of life after successful operative repair.[3] Patients with TOF have a decent quality of life and a survival rate of around 93 percent for 20 years following corrective surgery, 80 percent for 30 years after repair, and 72 percent for 40 years after repair.[4] Echocardiography is the primary procedure of diagnostic imaging in post-operative TOF patients, and allows for both qualitative observation of anatomical modification and thorough quantification of right ventricular volumes and function, right ventricular outflow tract, and pulmonary valve and pulmonary arteries as echocardiography is a noninvasive and useful tool for diagnoses.[5,6] Right ventricular diastolic dysfunction may be shown on Doppler echocardiography in the first week after TOF surgery and usually worsens with the transannular patch. Right ventricular outflow tract pulse demonstrates restrictive physiology and Doppler predicts a longer inotropic support period, a longer intensive care unit (ICU) care, and a greater diuretic dose.[7] Transatrial and transpulmonary approaches and restricted use of the transannular patch are two surgical modifications that have been frequently used to preserve pulmonary valve function. Our study's goal is to examine local outcome data in individuals with and without right ventricular diastolic function following TOF repair. Such findings will aid in the planning of future interventions to enhance the quality of life in patients.

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METHODOLOGY

The quasi-experimental study was conducted at the Department of Cardiology, National Institute of Cardiovascular Disease, Karachi Pakistan, from May

2021 to October 2021, after gaining approval of Institutional Ethics Review Committee. The total calculated sample size was 54 patients, with the help of Open Epi calculator for sample size calculation, with 27 in each group, and taking Mean±SD of ICU stay days after TOF repair as 5.1±3.7 days in patients with restriction in right ventricle and 2.8±2.0 days7 in patients.

Inclusion Criteria: All the patients above 5 months of age, of either gender, undergoing surgery for TOF were included.

Exclusion Criteria: Patients with left ventricle outflow tract, undergoing other concomitant cardiac procedures, received extensive radiation to the mediastinum, had infective endocarditis or any evidence of infection, or presented with cardiomyopathy, valvular heart disease, acute pericarditis and myocarditis, were excluded.

After receiving written/verbal informed permission, the patients provided a comprehensive history, including demographics. TOF was diagnosed on echocardiography with large ventricular septal defect with overriding of aorta and right ventricular hypertrophy and pulmonary stenosis. Patients were divided into two groups of 27 patients each, according to the Gatzoulis' criterion i.e. Group-A had right ventricle with restriction and Group-B had right ventricle without restriction (Figure). In a predesigned proforma, clinical indices and outcomes of right ventricular dysfunction were recorded. The tricuspid inflow velocity profile was measured using a Doppler sample implanted at the apex of the tricuspid valve, and right ventricular diastolic functional indices were determined using an apical four-chamber view. E and A wave velocities were measured, and their ratio (E/A) was determined. By extending the E wave's descending limb to the baseline, the deceleration time was computed. In a parasternal short-axis perspective, velocities of the right ventricular outflow tract were measured with a pulsed Doppler sample volume positioned directly below the pulmonary valve. The ejection time and the distance between the peak of the R wave on the contemporaneous ECG and the end of the pulmonary valve flow velocity signal were both measured. The time gap between the closure and opening of the tricuspid valve was identified as the isovolumetric contraction time (IVCT). The time gap between the termination of ventricular ejection and the commencement of ventricular filling was termed as isovolumetric relaxation time (IVRT).

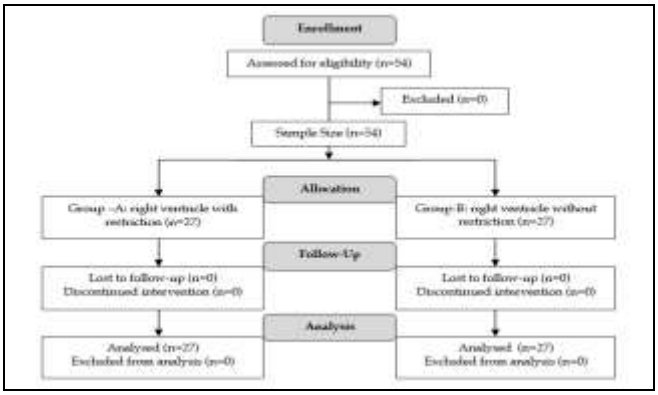

Figure: Patient Flow Diagram (n=54)

Data analysis was performed using Statistical Package for Social Sciences (version 21). Independent t-test was applied to see the mean difference of right ventricular diastolic functional indices and clinical outcome among patients with and without right ventricular restrictive physiology. Chi-square test was applied to see the association of transannular patch between groups. The *p*-value of ≤0.05 was considered as significant.

RESULTS

There were 38(70.4%) males and 16(29.6%) females. The mean weight of the patients was 14.92±7.29 kg. The mean age of the patients was 5.79±3.96 years. A significantly higher mean E/A ratio was observed in patients with non-restrictive physiology than that of with restrictive physiology, i.e., 1.21±0.22 vs. 1.04±0.14, (*p*-value 0.001, 95% CI 0.28 to 0.07). Similarly, a significantly higher mean E/A ratio was observed in patients with non-restrictive physiology than that of with restrictive physiology, i.e., 159.93±54.43 msec vs. 89.74±67.30 msec. (*p*-value <0.001, 95% CI -103.61 - -36.75). Moreover, a significantly higher mean IVRT was observed in patients with non-restrictive physiology than that of with restrictive physiology, i.e., 58.70±11.03 vs. 48.70±7.97 (*p*-value <0.001, 95% CI -15.26 - -4.74). However, IVCT was the only variable found significantly higher among patients with restrictive physiology as compared to the patients with non-restrictive physiology, i.e., 65.01±25.88 vs. 52.67±7.34 (*p*-value 0.021, 95% CI 1.94 - 22.72) (Table-I).

The clinical outcome showed that patients with restrictive physiology had significantly higher mean for aortic cross-clamp (*p*-value 0.004, 95% CI 3.54 to 17.35), ventilation time (*p*-value <0.001, 95% CI 20.03 - 31.22), ICU stay (*p*-value 0.014, 95% CI 0.19 - 1.65), drain time (*p*-value <0.001, 95% CI 105.29 - 31.21), and

duration of inotropes (*p*-value <0.001, 95% CI 29.09 - 51.79) (Table-II). Moreover, transannular patch was significantly higher among patients with restrictive physiology as compared to the patients without non-restrictive physiology, i.e., 23(85.2%) vs. 8(29.6%) (*p*-value <0.001) (Table-III).

Table-I: Mean Difference in Right Ventricular Diastolic Functional Indices Between Individuals With and Without Restrictive Physiology in the Right Ventricle, (n=54)

	Total (Mean±SD)	Restrictive Physiology (Mean±SD)	Non-Restrictive Physiology (Mean±SD)	*p*-value	95% CI
E wave velocity (cm/sec)	63.68±15.76	62.89±21.34	64.48±7.09	0.714	-10.27 - 7.09
A wave velocity (cm/sec)	57.15±17.21	61.59±21.13	52.70±10.79	0.057	-0.27 - 18.05
E/A ratio	1.12±0.20	1.04±0.14	1.21±0.22	0.001	-0.28 - -0.07
E/e'	7.45±1.27	7.18±1.25	7.71±1.26	0.134	-1.21 - 0.17
E wave deceleration time (msec)	124.83±70.21	89.74±67.30	159.93±54.43	<0.001	-103.61 - -36.75
IVRT	53.70±10.78	48.70±7.97	58.70±11.03	<0.001	-15.26 - -4.74
IVCT	58.83±19.84	65.01±25.88	52.67±7.34	0.021	1.94 - 22.72
MPI	0.45±0.16	0.42±0.12	0.49±0.19	0.078	-0.16 - 0.01
ET	257.74±48.41	254.52±62.51	261.52±23.92	0.615	-34.83 - 20.83

Independent t-test applied

Table-II: Clinical Outcome in Individuals With and Without Restricted Right Ventricular Physiology, (n=54)

	Total (Mean±SD)	Restrictive Physiology (Mean±SD)	Non-Restrictive Physiology (Mean±SD)	*p*-value	95% CI
Aortic cross-clamp (min)	70.78±13.59	76.01±12.11	65.56±13.15	0.004	3.54 - 17.35
Cardiopulmonary bypass (min)	116.68±20.57	121.37±19.48	112.01±20.92	0.095	-1.67 - 20.42
Ventilation (min)	64.29±16.43	77.11±11.34	51.48±9.01	<0.001	20.03 - 31.22
ICU stay (days)	4.48±1.41	4.94±1.64	4.01±0.94	0.014	0.19 - 1.65
Drain time (hours)	85.29±31.64	105.29±31.21	65.89±16.14	<0.001	25.84 - 52.97
Duration of Inotropes (hours)	80.67±28.98	100.88±26.88	60.44±12.31	<0.001	29.09 - 51.79

Independent t-test applied

Table 3: Comparison of Restrictive Physiology with Transannular Patch (n=54)

Transannular Patch	Restrictive Physiology	Non-Restrictive Physiology	*p*-value
Yes	23(85.2)	8(29.6)	<0.001
No	4(14.8)	19(70.4)	
Total	27(100)	27(100)	

DISCUSSION

Rapid right ventricular dilatation was revealed to be an independent predictor of restrictive right ventricular physiology.[8,9] Previous research on the impact of restricted right ventricular physiology on right ventricular mechanics and clinical consequences was inconclusive. Early restrictive right ventricular physiology following TOF surgery has been linked to a negative postoperative outcome.[9,10] As per current study findings, patients with restrictive physiology had significantly higher mean for aortic cross-clamp, ventilation time, ICU stay, drain time, and duration of inotropes. From echocardiographic data, Gatzoulis *et al*.[11] revealed that individuals with restricted right ventricular physiology exhibited worse exercise performance; nonetheless, patients with restrictive right ventricular physiology performed better than patients without restrictive right ventricular physiology. A probable mechanism is myocardial fibrosis, which causes lower right ventricular compliance and, as a result, limits growing right ventricular dilatation.[12] One study compared the right ventricular outcome between those with and without restrictive physiology,[13] with the mean age of the patients being 4.4±2.3 years in right ventricular restriction and 5.5±3.1 years in no restriction group. In right ventricular restriction, the mean weight, aortic cross clamp and cardiopulmonary bypass was 12.3±4.6 kg, 69.23±18.96 min and 124.38±34.24 min respectively. In no right ventricular restriction, the mean weight, aortic cross clamp and cardiopulmonary bypass was 14.9±2.9 kg, 63.36±17.23 min and 112.89±27.31 min respectively. The ventilation and ICU stay was found as 72.5±19 hr and 5.1±3.7 days in RV restriction and 42.2±23 hr and 2.8±2.0 days in no restriction group respectively. In right ventricular restriction, the mean drain time, Inotropes duration and Diuretics frusemide was 116.5±64.2hr, 108.3±56.2hr, and 2.89±0.86mg/kg respectively. In no right ventricular restriction, the

mean weight, aortic cross clamp and cardiopulmonary bypass was 60.8±60.1hr, 55.5±28.3hr, and 1.74±0.64mg/kg respectively. The transannular patch was found 58.3% in right ventricular restriction and 19.2% in no restriction group.

According to the current study findings, patients with non-restrictive physiology had a considerably greater mean E/A ratio than those with restrictive physiology. Similarly, patients with non-restrictive physiology had a much greater mean E/A ratio than those with restrictive physiology. Furthermore, individuals with non-restrictive physiology had considerably greater mean IVRT than those with restrictive physiology. Biventricular systolic function is often retained in the majority of patients but right ventricular diastolic function has been reported to show deterioration in various stages of surgical follow-up.[10-14] Restrictive right ventricular physiology may be connected to a complex postoperative development.[11,15-17] As Pakistan is facing a big challenge in dealing with the increasing prevalence and burden of congenital heart disease and other related issues,[18-19] there is a dire need of further studies.

LIMITATION OF STUDY

The study has not reported laboratory characteristics and other related clinical findings.

CONCLUSION

There was a significant difference in the surgical outcomes of TOF patients with and without right ventricular diastolic dysfunction. In individuals with limited right ventricular physiology, careful monitoring may be required. Furthermore, further research is needed to have a better understanding of these changes.

Conflict of Interest: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SA & FUR: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

AKA & AR: Data acquisition, data analysis, critical review, approval of the final version to be published.

ASS: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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