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USE OF RIGHT ATRIAL APPENDAGE FOR PULMONARY VALVE RECONSTRUCTION IN TETRALOGY OF FALLOT REPAIR: A SINGLE-CENTER STUDY

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ABSTRACT

Preventing postoperative pulmonary regurgitation (PR) is critical for favorable outcomes following Tetralogy of Fallot (TOF) repair. The right atrial appendage (RAA) valve for right ventricular outflow tract (RVOT) reconstruction is a novel technique that offers a promising alternative when the native pulmonary valve cannot be preserved. This cross-sectional study evaluated the use of the RAA valve in 102 consecutive patients who underwent TOF repair at our institution between December 2023 and May 2025. The mean age was 6.5 years (range: 4 months–32 years). There were four deaths, none attributed to RAA valve use. Early postoperative echocardiography revealed trivial or no PR in 61 patients, mild PR in 33, and moderate PR in 8, with no severe PR. None developed significant RVOT obstruction. The mean tricuspid annular plane systolic excursion (TAPSE) was 14 mm. The average cardiopulmonary bypass and aortic cross-clamp times were 98 and 78 minutes, respectively. Postoperative complications included two re-openings for bleeding or tamponade, three strokes, six reintubations, five cases of renal dysfunction (one requiring

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dialysis), one heart block not requiring pacemaker, and one superficial wound infection. Overall, RAA valve reconstruction appears feasible, safe, and effective in reducing early PR, with encouraging short-term outcomes. Longer follow-up is warranted to assess durability and its role in delaying pulmonary valve replacement.

INTRODUCTION

Tetralogy of Fallot (TOF) is the most common cyanotic congenital heart disease, defined by four structural anomalies: ventricular septal defect, right ventricular outflow tract obstruction, overriding aorta, and right ventricular hypertrophy. [1,2] TOF is the most frequently occurring cyanotic congenital heart defect, affecting approximately 0.34 out of every 1,000 live births.[3] The first reported surgical correction of TOF was performed in 1954 on a group of 106 individuals, with a 30-year survival rate of 77%.[4] Without surgical treatment, the condition has a poor prognosis, with survival rates dropping to 66% by age 1, 40% by age 3, 11% by age 20, and just 3% by age 40.[5] Early surgical repair remains the standard approach to prevent hypoxemia and long-term ventricular damage [6]. However, traditional methods, especially those involving trans-annular patches, often compromise the pulmonary valve, leading to pulmonary regurgitation and subsequent right ventricular dilation and dysfunction [7,8]. Although right ventricular volume load due to severe pulmonary regurgitation can be tolerated for years, there is now evidence that the compensatory mechanisms of the right ventricular myocardium ultimately fail and that if the volume load is not eliminated or reduced the dysfunction might be irreversible. [9] Preserving or reconstructing pulmonary valve function during TOF correction has emerged as a critical factor in reducing late complications, such as arrhythmias, heart failure, and the need for reoperation.[7,10] One emerging method involves creating a functional neo pulmonary valve using the autologous RAA. This innovative technique, introduced by Amirghofran [11]and recently applied in clinical settings, utilizes native tissue to reconstruct a bicuspid valve, which may provide durability, growth potential, and fewer prosthetic-related complications in pediatric patients [10,11]. Pulmonary regurgitation remains a significant challenge following conventional TOF repair,leads to progressive right ventricular dysfunction, arrhythmias, and long-term morbidity. To address these concerns, reconstructive strategies using autologous tissue have emerged as promising alternatives. The RAA has been proposed as a neo-pulmonary valve due to its potential advantages such as growth potential, lower risk of thrombosis, and elimination of prosthetic-related issues. While the technique demonstrates promising short- and mid-term outcomes, there is a lack of comprehensive international research, and clinical data from local settings is particularly scarce. This study aims to evaluate the effectiveness of RAA-based pulmonary valve reconstruction in pediatric TOF repair, with particular emphasis on mortality, pulmonary regurgitation, postoperative right ventricular function, early postoperative complications, and mid-term rates of re-intervention.

MATERIAL AND METHODS

This cross sectional study was conducted at Bahria International Hospital Orchard Lahore from 1st December 2023 to June 2025. A total of 102 patients were included, all of whom underwent surgical repair of TOF during this period. The study included all patients undergoing tetralogy of fallot repair in whom there was need for trans-annular patch and could not preserve pulmonic valve. Postoperative outcomes were assessed during the in-hospital stay and at follow-up visits up to 30 days post-surgery. No mid- or long-term follow-up was available at the time of analysis.

Pre-operatively patients were assessed according to American Heart Association (AHA) and American College of Cardiology (ACC) guidelines, and a decision for surgery was made after involving multidisciplinary teams. Key patient characteristics, including age and gender, were recorded. Intraoperative parameters recorded were cardiopulmonary bypass time and cross clamp time. Primary outcome of study was mortality and degree of post-operative pulmonary regurgitation. Secondary outcomes were incidence of post-operative stroke, reopening, heart block, renal dysfunction, reintubation, prolong ICU stay and wound infection. Postoperative pulmonary valve function was assessed intraoperatively using epicardial echocardiography and during follow-up visits. The severity of pulmonary regurgitation was categorized as none/trivial, mild, moderate, or severe The collected data were analyzed using the Statistical Package for the Social Sciences (IBM SPSS V.21.0). The Institutional Review Board of the hospital approved this study and waived the need for patient consent.

RESULTS

The study included total of 102 patients which were operated at a single center with single operating surgeon during 1.5 year period (Dec 2023 to May 2025). 61% of study population was male and rest female. The mean age was 6.5 years with range from 4 months to 32 years. Shown in Table1.

Table1.

PREOPERATIVE VARIABLES		
S. No	Variable	Value (mean)
1	Total patients	102
2	Age (years)	6.5 years
3	Male	62 (61 %)
4	Female	40 (39%)

Mean cardiopulmonary bypass time was 98 minutes ranging from 62 minutes to 118 minutes. The average cross clamp time was 78 mints ranging from 52 mints to 90 minutes. As shown in Table2.

Table2.

INTRAOPERATIVE VARIABLES		
S.No	Variable	value
1	Cardiopulmonary bypass time	98 mints
2	Cross clamp time	78 mints

The primary outcome of study was in hospital mortality during the index admission which was 3.9 %. In all of these patients, mortality was not directly related to the use of right atrial appendage valve. The degree of postoperative pulmonary regurgitation was assessed using epicardial echo intraoperatively and on follow up. Patients were divided into 4 groups. 60% of

patients had no or trivial pulmonary regurgitation and 32 % patients had only mild regurgitation. This comprises total of 92 % study population falling in mild/less than mild pulmonary regurgitation.8% patient had moderate pulmonary regurgitation and none had severe pulmonary regurgitation. As shown in Table3.

Table3.

POSTOPERATIVE VARIABLES		
S. No	Variable	value
1	Mortality	4 (3.9%)
2	No or trivial pulmonary regurgitation	61 (60%)
3	Mild pulmonary regurgitation	33 (32%)
4	Moderate pulmonary regurgitation	8 (8%)
5	Severe pulmonary regurgitation	0
6	Severe RVOT obstruction	0
7	TAPSE	14 (mean)
8	Reopening for bleeding/ tamponade	2 (2%)
9	Heart block	1 (1%)
10	Stroke	3 (3%)
11	Renal dysfunction	5 (4%)
12	Liver dysfunction	5 (5%)
13	Prolong ICU stay	8 (7%)
14	Reintubation	6 (5%)
15	Wound infection	1 (1%)

None of patient had severe residual RVOT. Mean TAPSE was 14 ranging from 7 to 20. This indirectly shows the degree of RV dysfunction. 2% patients had reopening for bleeding in ICU. 1 patient had incomplete heart block that did not required pacemaker. 3% patient had postoperative stroke diagnosed on CT. 1 had hemorrhagic stroke that required emergency drainage and 2 had ischemic stroke managed conservatively. 5 patients had renal and liver dysfunction but none required dialysis. 7% had prolong ICU stay (more than 7 days). 6 patients required reintubation due to respiratory complications. 1 patient had superficial wound infection.

DISCUSSION

The surgical repair of tetralogy of fallot has advanced significantly over time, with preservation of right ventricular function and prevention of pulmonary regurgitation as key determinants for long-term treatment outcomes. In conventional surgical repair of tetralogy of fallot, pulmonary

regurgitation is a common and unavoidable outcome that often leads to right ventricular dilation and failure over time [12].

This study highlights a new approach towards repairing TOF, which uses the right atrial appendage as a neo-pulmonary valve for the repair of TOF. The results were favorable, with 92% of patients with trivial to mild PR, which were similar to the results reported by Amirghofran et al.(2021), which shows that using RAA for the repair of TOF is related to good mid-term outcomes as compared to conventional procedures [11]. In our study, only 8% of the patients shoed moderate pulmonary regurgitation, while none had severe PR following TOF repair using the RAA as a neo-pulmonary valve In contrast, previously published research has documented a notably higher incidence of both moderate and severe pulmonary regurgitation in the early postoperative period, particularly in patients undergoing conventional trans-annular patch [13,14]. This marked difference highlights the potential advantage of the RAA technique in significantly reducing the incidence of early moderate and severe PR compared to trans-annular patch approach.

The reason behind using RAA for TOF repair lies in its histology and structural compatibility with pulmonary circulation. Being autologous, the RAA decreases the complications associated with prosthetic valves, such as infection, thrombosis, and lack of potential for growth. Moreover, the use of RAA may help decrease the rate of re-interventions, which remains a common complication of TOF repair with prosthetic or homograft valves [15].

The mean TAPSE score in our study was 14, which shows preserved or mildly impaired right ventricular function. Although this value is slightly lower than the reference range but it is still within acceptable limits and consistent with the result of A. Guariento et al(2022), which shows that the function of the right ventricle is relatively preserved following valve-sparing or valve-reconstructing procedures [16].

The complication rate in our study, including stroke (3%), reintubation (5%), and renal dysfunction (4%), is within the acceptable range for complex congenital cardiac surgeries [17]. The low in-hospital mortality rate (3.9%) is consistent with other regional and international hospitals, demonstrating the feasibility and safety of this technique [18].

The short-term outcomes from our center show that using the RAA valve for pulmonary valve reconstruction during TOF repair is a potentially superior alternative when native valve preservation is not possible. This technique may bridge the gap between early surgical success and delayed valve replacement, particularly in pediatric populations where prosthetic valve durability and somatic growth are major considerations.

However, there are certain limitations to our study. This is a single-center study with a very short period of follow-up. Although the short-term outcomes are promising, the long-term durability, functional capacity, and freedom from re-intervention of the RAA valve are yet to be established. Further multicenter studies with long-term follow-up are necessary to verify these early results.

CONCLUSION

The RAA valve construction is an emerging technique to prevent pulmonary regurgitation after the TOF repair. The immediate outcomes are very promising as shown in our study. A longer follow-up period is planned to confirm if right atrial appendage valve can eliminate or significantly delay the need for pulmonary valve replacement in these patients.

ABBREVIATIONS

TOF: Tetralogy of Fallot

RAA: Right atrial appendage

RVOT: Right ventricular outflow tract
PR: Pulmonary regurgitation
PI: Pulmonary Insufficiency
CPB: Cardiopulmonary bypass
TAPSE: Tricuspid annular plane systolic excursion
ICU: Intensive care unit
ACC: American College of Cardiology
AHA: American Heart Association
IRB: Institutional Review Board
CT: Computed tomography
SPSS: Statistical Package for the Social Sciences

ETHICS APPROVAL

The study was approved by the Institutional Review Board of Bahria International Hospital Orchard, Lahore. The requirement for patient consent was waived.

CONSENT FOR PUBLICATION

Not applicable.

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