



RVOT RECONSTRUCTION STRATEGIES IN TOF: SINGLE CENTER EXPERIENCE

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Abstract:

Introduction: While dealing with right ventricular outflow tract in TOF, pulmonary regurgitation due to pulmonary valve dysfunction is common. When the pulmonary valve cannot be preserved,¹¹ some sort of pulmonary reconstruction is required to prevent pulmonary regurgitation. The strategies to reconstruct pulmonary valve include creation of mono cusp valve, either with autologous pericardium, bovine jugular vein mono cusp valve or poly tetra fluoroethylene (PTFE). More recently, right atrial appendage has been used to reconstruct pulmonary valve.

Patients and methods: All the data was retrieved from data base. Data of all patients who underwent complete repair of tetralogy of Fallot's from January 2019 to December 2023 (5 years) at Children's Hospital Lahore/ university of Child Health Sciences Lahore. Different techniques to preserve/reconstruct pulmonary valve were studied. Primary endpoint of interest was in hospital mortality.

Results: 841 underwent complete repair for tetralogy of Fallot's. Mean age of the patients was 2.9 years and mean weight was 9.1 Kg. In 179 patients, pulmonary valve was preserved (21%). Trans annular patch with mono cusp valve was used in 605 patients. PTFE mono cusp was used in 164, and autologous untreated pericardial mono cusp was used in 441 patients..

Conclusions: Efforts should be made to preserve pulmonary valve in tetralogy of fallot's surgery but if valve sparing is not possible, there are variety of techniques to reconstruct right ventricular outflow tract which can be used to prevent pulmonary regurgitation and its deleterious effects in peri operative period

Key words tetralogy of fallot, mono cusp, right atrial appendage

Introduction

Tetralogy of Fallot (TOF) is the most common type of cyanotic congenital heart disease (CHD) with the incidence of 0.34 per 1000 live births¹. While a lot of efforts are being made for the interventional management of TOF², surgery is the treatment of choice at the moment. Complete surgical repair involves ventricular septal defect (VSD) closure and right ventricular outflow tract (RVOT) reconstruction.³ While dealing with right ventricular outflow tract in TOF, pulmonary regurgitation due to pulmonary valve dysfunction is common. Pulmonary regurgitation (PR)

initially was thought to be a benign hemodynamic residual lesion but subsequently it was found that it was associated with lower exercise performance and gradual RV dilation. RV dilation, in turn, was associated with ventricular arrhythmia, ventricular dysfunction higher risk of sudden cardiac death.⁴ In current era most of the surgeons either try to preserve the pulmonary valve or reconstruct the pulmonary valve to prevent pulmonary regurgitation and its sequelae.

The strategies to prevent pulmonary regurgitation include pulmonary valve preservation⁵, pulmonary valve augmentation⁶, infundibular patch⁷, T shaped infundibular incision⁸, intra operative balloon valvuloplasty of pulmonary valve⁹ or creation of bi orifice right ventricle out flow tract (RVOT)¹⁰

When the pulmonary valve cannot be preserved,¹¹ some sort of pulmonary reconstruction is required to prevent pulmonary regurgitation. The strategies to reconstruct pulmonary valve include creation of mono cusp valve, either with autologous pericardium, bovine jugular vein mono cusp valve or poly tetra fluoroethylene (PTFE) .¹²⁻¹⁴ . more recently, right atrial appendage has been used to reconstruct pulmonary valve.¹⁵ Sometimes when right ventricle out flow tract is narrow or left anterior descending coronary artery is crossing RVOT, Right ventricle to pulmonary artery conduit is used.¹⁶

In this article we have reviewed our experience with tetralogy of Fallot's repair, pulmonary valve strategies and their short-term outcomes.

Patients and methods:

It is retrospective observational study. All the data was retrieved from data base. Data of all patients who underwent complete repair of tetralogy of Fallot's from January 2019 to December 2023 (5 years) at Children's Hospital Lahore/ university of Child Health Sciences was studied after getting approval from the hospital ethical review committee.

The pulmonary annulus z-score for all study patients was determined using the online calculator based on the Detroit score.¹⁷

Different techniques to preserve/reconstruct pulmonary valve were studied. Primary endpoint of interest was in hospital mortality. Secondary endpoints were residual RVOT obstruction and pulmonary regurgitation.

Data was entered in SPSS version 14. Variables with a normal distribution are expressed as mean with range. Variables without a normal distribution are expressed as median and range. Descriptive statistics are used to present basic patient characteristics

Surgical technique:

After taking consent, patients were taken to operation room where they were anesthetized in standard fashion. All the patients were approached through median sternotomy. After putting the patients on cardiopulmonary pass with aortic and bicaval cannulation, all the patients were approached through trans atrial trans pulmonary approach. Obstructive muscle bundles were cut and VSD was closed through right atrium.

Efforts were made to preserve pulmonary valve with trans atrial and trans pulmonary RVOT muscle resection. In some patients infundibular patch was used to preserve pulmonary valve. Pulmonary valve size was assessed with Hagar sizer. If the Z score of the pulmonary valve annulus was < -2 , trans annular incision was made. When ever trans annular incision was made, some sort of pulmonary valve reconstruction was made. Our preference was to use PTFE for pulmonary valve mono cusp but if PTFE was not available, autologous pericardial mono cusp was made to prevent pulmonary regurgitation. In some patients RV to PA conduit was used while in some right atrial appendage was used to reconstruct pulmonary valve.

After coming off CPB, intra operative echocardiogram was done for each patient and if there was residual gradient across RVOT of > 45 mmHg, CPB was again established and residual obstruction was corrected.

Results

From January 2019 to December 2023, 5039 patients underwent cardiac surgery at our institute. 841 underwent complete repair for tetralogy of Fallot's. (16% of all surgeries).

As shown In table 1, Mean age of the patients was 2.9 years and mean weight was 9.1 kg. Out of these ,38 patients had previous BT shunt which was closed at the time of complete repair.

Mean cardiopulmonary bypass time was 109 minutes and mean cross clamp time was 78 minutes.

As shown in table 1 , in 179 patients , pulmonary valve was preserved (21 %). In 23 patients , infundibulum was opened longitudinally and RVOT muscle resection was carried out through the infundibulum without opening the annulus of pulmonary valve, thus preserving the pulmonary valve function.

Trans annular patch with mono cusp valve was used in 605 patients. Our preference was to use 0.1 mm thick PTFE membrane for the construction of mono cusp pulmonary valve but its cost and availability at our institute lead us to use it only in 164 patients ,in rest of the patients we used untreated autologous pericardium for mono cusp pulmonary valve construction. There was no significant difference in the short term out come in these two sub groups(PTFE / pericardial mono cusp) which had same mortality rate.

More recently we have started using right atrial appendage to reconstruct pulmonary valve which has shown good results. Double barrel RVOT was made in 2 patients with coronary artery crossing RVOT. In this technique, a 6 MM PTFE tube is implanted between RV and PA pulmonary valve keeping annulus of the pulmonary valve intact. Most of the patients died of right ventricular dysfunction and low cardiac output syndrome.

Low mortality(1.6%) in patients in whom pulmonary valve was preserved, can be attributed to milder form of the disease in which there was only sub valvular obstruction with well developed pulmonary valve.

Highest mortality(21%) was noted in sub group in which RV to PA conduit was used (Rastelli operation). The most common indication for Rastelli operation was narrow RVOT in elder kids who do not tolerate pulmonary regurgitation well. Other indication was coronary artery crossing RVOT. We make tri leaflet handmade conduit with bovine pericardium and PTFE cusps¹⁸. High mortality in this sub group can be attributed to severe nature of the disease with valvular, sub valvular and branch pulmonary arteries stenosis. Fig 1 and 2 summarize the results of our study.

Overall mortality was 7.4%(63/841)

Table 2 shows the complications. Despite all the measures to prevent pulmonary regurgitation, on echocardiogram, 100% competent pulmonary valve was achieved in only 13%, while mild , moderate and severe pulmonary regurgitation was present in 55%, 23% and 9% respectively.

Discussion

While in the modern world, the mortality rate of TOF repair has significantly improved in recent years with peri operative mortality of 3 %. ^{19 - 21} mortality rate in our study is higher than the international standards which can be attributed to lack of ECMO, respiratory infections, shortage of trained staff in ICU. Our results are comparable to study by Poolthananant ²² which had mortality of 23% in trans annular patch group and 7 % in pulmonary valve preserved group.

While some studies have reported that pulmonary valve sparing is possible in 80 percent ²³, in our study only 21 percent of the patients underwent valve sparing surgery. We should re consider our strategy and perhaps we are going for trans annular patch un necessarily .

Trans annular patch with mono cusp was the most common strategy for RVOT reconstruction in our study. The advantages of mono cusp in terms of reducing the hospital stay and cost of treatment are evident ²⁴. Although the prevention of PR is not long term and most of these cusps stop functioning after 2 years, ²⁵ the main advantage is in peri operative period where the pressure loaded right ventricle due to outflow obstruction is prevented from volume overload if we prevent the pulmonary regurgitation. While the debate of mono cusp valve or no mono cusp valve is ongoing, ²⁶

in our institute , we have stopped using trans annular patch alone . when ever there is need for trans annular patch, we use mono cusp valve.

We have very limited experience with right atrial appendage usage at pulmonary position and double barrel RVOT ²⁷. In our study we have never used intra operative balloon valvuloplasty ²⁸ for pulmonary valve and never used bi orifice RVOT techniques ¹⁰.

Unavailability and cost of homografts made us construct hand made RV to PA conduits which work well in different diseases. We published how do we make and our experience with handmade conduits in 2020 in which 6 patients with TOF underwent Rastelli operation ²⁹

CONCLUSION

Efforts should be made to preserve pulmonary valve in tetralogy of fallot’s surgery but if valve sparing is not possible, there are variety of techniques to reconstruct right ventricular outflow tract which can be used to prevent pulmonary regurgitation and its deleterious effects in peri operative period .

Number	841	range
Age	2.9 years	6 months – 15 years
Male to female ratio	3:2	
Previous BT shunt	38 (4,5%)	
Weight	9.1 kg	6 kg – 56 kg
Cross clamp time	78 minutes	40 – 128 minutes
Cardiopulmonary bypass time	109 minutes	55 – 207 minutes
PV z score	-2	-4 to 1
Pre op RVOT gradient	68mmHg	53- 97mmHg
Post op RVOT gradient	24mmHg	9-45mmHg
Pulmonary valve preserved	179(21%) Infundibular patch 23	
Monocusp	Autologous pericardium 441 PTFE 164	
ICU stay	63 hours	24 – 245 hours
Inotropic support	54 hours	6 – 207 hours

Table 1 patients characteristics

Mortality	63/841(7.4%)	
PV preserved	3/ 179 (1.3%)	
TAP autologous pericardial monocusp	37/441 (8.3%)	
TAP with PTFE monocusp	14/164(8.5%)	
RV to PA conduit	9/42(21%)	
Pulmonary regurgitation	739/841(87%)	
Mild	466 (55%)	
Moderate	194(23%)	
Severe	79(9%)	
Pulmonary hemorrhage	2	
Stroke	1	

Table 2 complications

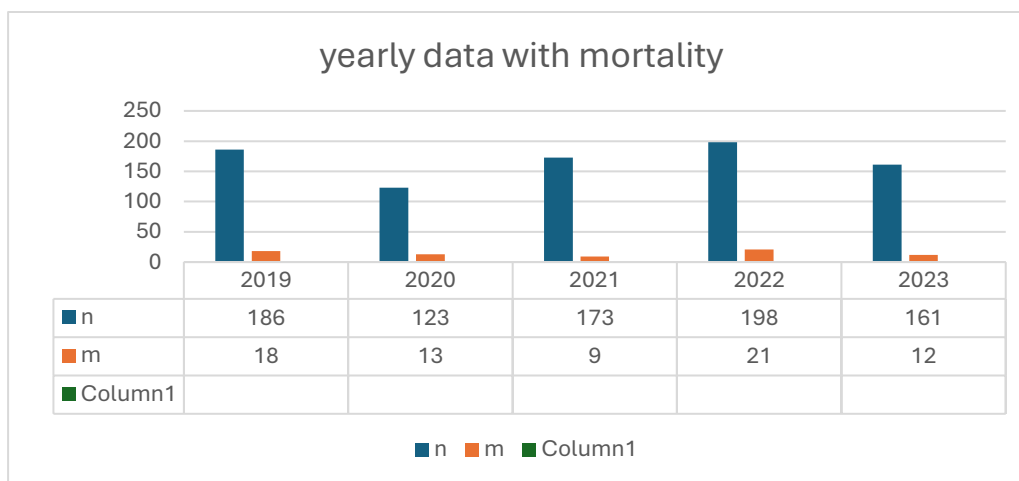


Fig 1. Yealy data with mortality, n number of patients m mortality

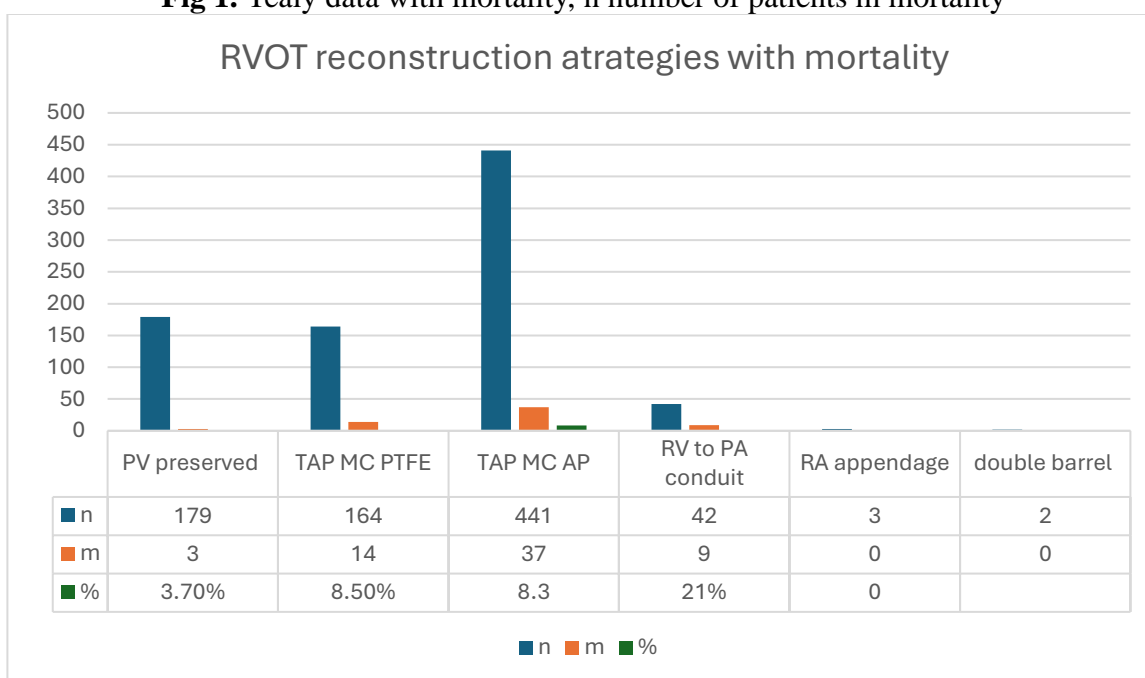


Fig 2 RVOT reconstruction strategies with mortality n number of cases m mortality % percentage of mortality

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