Concomitant pulmonary valve replacement with intracardiac repair for adult tetralogy of Fallot

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ABSTRACT

Objectives : **Adult patients undergoing tetralogy of Fallot (TOF) repair have a higher risk of mortality compared to pediatric patients. Pulmonary regurgitation (PR) further predisposes these patients to heart failure, arrhythmias, and sudden death. Pulmonary valve replacement (PVR) may improve the symptoms in these patients but, fails to reverse the other deleterious effects. Aim of our study was to evaluate the effect of concomitant PVR with TOF repair on right ventricular (RV) parameters, cardiopulmonary exercise capacity, and bioprosthetic valve durability at mid-term.**

Materials and Methods : **Between January 2013 and August 2018, 37 adolescents and adults with TOF who had hypoplastic pulmonary annulus underwent concomitant TOF repair with PVR at our institute. We retrospectively collected the data from the hospital records including follow-up.**

Results : **Mean age of the patients was 18.48 ± 7.53 years. Bioprosthetic valve size ranged from 19 mm to 25 mm. There was no early or late mortality. No patient had developed significant perioperative complications. At a mean follow-up of 53.3 ± 16.4 months, there was no significant change in mean QRS duration, RV function, RV end-systolic and end-diastolic dimensions, RV myocardial performance index, and functional status (including NYHA class and 6-min walk test) compared to at-discharge values. Four patients developed prosthetic valve degeneration with mild PR and without significant increase in gradient.**

Conclusion : **Concomitant PVR with TOF repair in adult provides excellent mid-term outcome, with a minimal rate of pulmonary valve degeneration. It not only eases the early postoperative course but also preserves the RV function as well as functional status at mid-term.**

Keywords : Bioprosthetic valve, pulmonary valve, tetralogy of Fallot

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INTRODUCTION

Pulmonary regurgitation (PR) is an unfortunate consequence of trans-annular patch (TAP) in patients undergoing tetralogy of Fallot (TOF) repair. Longstanding PR results in right ventricular (RV) dysfunction, prolongation of QRS duration, supraventricular and ventricular arrhythmias, and reduced life expectancy.[1-13] Therefore, symptomatic chronic PR is an indication for pulmonary valve replacement (PVR). However, studies have shown that even after PVR, there is no significant improvement in the uncorrected RV ejection fraction (UnRVEF) and the corrected RVEF also improves only to the extent of preoperative UnRVEF. Both these facts reiterate that PVR does not improve RV dysfunction.[8-10] Further, PVR late after the onset of PR may partially or completely fail to normalize RV end-diastolic volume and end-systolic volume (ESV), QRS duration, and exercise capacity.[4,7] Further, PVR also fails to reduce the incidence of ventricular tachycardia (VT) or sudden death once the QRS duration is >180 ms.[7,12] Hence, Jost *et al.* have advocated concomitant PVR in adult patients with TOF who have hypoplastic pulmonary annulus (HPA).[1] However, data are still limited about the outcome of concomitant PVR with TOF repair in adolescent and adult patients. The aim of our retrospective study was to evaluate the effect of concomitant PVR on RV parameters, cardiopulmonary exercise capacity, and bioprosthetic valve durability at mid-term.

MATERIALS AND METHODS

The study protocol was approved by the Ethics Committee of our institute and patient's consent was waived off in view of the retrospective nature of the study. Between January 2013 and August 2018, 37 adolescents and adults with TOF and HPA underwent concomitant TOF repair with PVR at our institute. We retrospectively collected perioperative and follow-up data from the hospital records. Perioperative data included symptoms and previous palliation; electrocardiography (ECG) for rhythm, arrhythmias, and QRS duration; echocardiography; computed tomography pulmonary angiography (CTPA) and cardiac catheterization for major aortopulmonary collaterals (MAPCAs) and their management; operative procedure-type and size of bioprosthesis, postrepair right ventricle to left ventricle pressure ratio (pRV/LV); inotropic score, duration of mechanical ventilation, intensive care unit (ICU), and hospital stay, and postoperative mortality.

Surgical technique

All patients were operated under moderate hypothermic (28°C–32°C) blood cardioplegic arrest through midline sternotomy. The approach used was through the right atrium-right ventricle. Significant MAPCAs amenable to occlusion with coil were occluded day before surgery. MAPCAs not amenable for coil occlusion and/or patent palliative shunts were ligated immediately after the commencement of cardiopulmonary bypass. Right ventriculotomy was extended across the pulmonary annulus. After the resection of hypertrophied infundibular muscle bundles and patch closure of the ventricular septal defect, aortic bioprosthesis was sutured at pulmonary annulus facing downward using 5-0 prolene continuous sutures. The residual defect anteriorly was repaired with fixed autologous pericardium suturing the rest of the valve to the pericardium, anteriorly. Postrepair, anterior surface of the heart and great vessels were covered with pericardial membrane (0.1 mm enhanced-polytetrafluoroethylene (Gore-Tex™) patch) to facilitate safe sternotomy during inevitable future re-operations.

All patients were continued on oral warfarin for 3 months postoperatively and international normalized ratio was maintained between 2 and 3.

Follow-up data

Follow-up data were collected till December 2018. Follow-up data included clinical symptoms, ECG, and echocardiography. We also collected the data for 6 min walk test at discharge and during follow-up.

Echocardiography data for LV included ejection fraction (LVEF). For RV included pulmonary valve (PV) mean (Gmean) and maximum (Gmax) gradient, systolic pressure (RVSP), end-diastolic area (RVEDA), end-systolic area (RVESA), myocardial perfusion index (RVMPI) (Tei index), fractional area change (RVFAC), tricuspid annular plane systolic excursion (TAPSE), and any residual surgical lesion. RV outflow tract obstruction (RVOTO) was graded according to the American Society of Echocardiography guidelines for pulmonic stenosis (PS).[14]

Statistical analysis

Statistical analyses were performed with the SPSS 22.0 software (SPSS, Inc., Chicago, IL, USA). Continuous variables are expressed as mean with standard deviations. Categorical data are expressed as percentages. Continuous variables in the immediate postoperative period and last follow-up were compared using Students paired *t*-test. $P < 0.05$ was considered significant.

RESULTS

The demographic profile of the patients is shown in Table 1. The mean age of the patients was 18.48 ± 7.53 years and there were 16 males and 21 females. All patients were in sinus rhythm with mean QRS duration of 92 ± 6.5 ms. Four patients had been palliated previously with modified Blalock Taussig shunt

Table 1: Demographic, clinical and echocardiographic variables of tetralogy of Fallot repair with pulmonary valve replacement patients

Variables	Mean±SD (range) (*n*=37), *n* (%)
Age (years)	18.48±7.53
Median age (years; range)	15 (8-39)
BSA (m^2)	0.94±0.6
Gender (male/female)	16/21 (43.2%/56.7%)
Preoperative SpO_2 (%)	86.5±8.15
Preoperative hemoglobin (g/dl)	13.73±2.48
Symptoms	
Dysponea	35 (94.6)
Cyanosis	24 (64.8)
Clubbing	27 (72.9)
Dizziness/syncope	6 (16.2)
Palpitation	10 (27)
Hemoptysis/endocarditis	0
Arrhythmias	0
Diagnosis	
TOF	23 (62.1)
TOF with absent pulmonary valve syndrome	10 (27)
TOF with atrio-ventricular canal defect	4 (10.8)
Pulmonary stenosis gradient (mmHg)	103.16±13.32
Associated anomalies	
Patent foramen ovale	22 (59.5)
Ostium secundum atrial septal defect	4 (10.8)
Persistent LSVC	4 (10.8)
Single coronary	2 (5.4)
Right aortic arch	12 (32.4)
Severe aortic regurgitation	1 (2.7)
Left isomerism	1 (2.7)
Previous mBT shunt surgery	4 (10.8)
QRS duration (ms)	92±6.5
CTPA	
Pulmonary annulus *Z* score	–4.7±1.45
RPA-*Z* score	1.85±1.57
LPA-*Z* score	2.28±1.2
Nakata index (mm^2/m^2)	428±243
MAPCAs	
Direct	10 (27)
Indirect	12 (32.4)
Coil occlusion of MAPCA	5 (13.5)

SpO_2: Oxygen saturation, TOF: Tetralogy of Fallot, LSVC: Left superior vena Cava, mBT: modified Blalock Taussig, CTPA: Computed tomography pulmonary angiography, RPA: Right pulmonary artery, LPA: Left pulmonary artery, MAPCAs: Major aorto-pulmonary collaterals, BSA: Body surface area

and shunt was patent in three patients (blocked in one patient). A total of 10 patients had significant MAPCAs on preoperative CTPA. Total 12 MAPCAs were coil occluded in five patients, preoperatively. Preoperative TAPSE was 1.89 ± 0.3 cm.

Operative data are shown in Table 2. A bioprosthetic valve was used for PVR in all the patients and size ranged from 19 mm to 25 mm. 19 mm valve was used in three patients with BSA of 0.6, 0.67, and 0.7 mm/m^2. Total 8 MAPCAs in five patients (13.5%) were ligated surgically at the time of TOF repair. Postoperative pRV/LV ratio was 0.55 ± 0.10 (range 0.3–0.7) and RV to PA gradient was 13.3 ± 5.7 mmHg. There was no PR in any patient.

Postoperative data are shown in Table 3. The mean vasopressor inotropic score was 13.16 ± 3.32. The mean duration of mechanical ventilation was 10.37 ± 6.2 h and ICU stay was 3.5 ± 0.9 days. There was no operative mortality. No patient had developed low cardiac output syndrome (LCOS), acute renal failure (ARF), ventricular dysfunction, arrhythmias, or sepsis. Postrepair, mean central venous pressure (CVP) was 7 ± 2.1 mmHg, and mean RV end-diastolic pressure (RVEDP) was 8.5 ± 3.4 mmHg. Two patients developed pleural effusion that required drainage and two patients required re-intubation. At discharge, all patients were in sinus rhythm, and the mean QRS duration was 103 ± 6.7 ms. In echocardiography, mean RVEDA and mean RVESA were 13.7 ± 1.2 cm^2 and 8.53 ± 1.13 cm^2, respectively. RVMPI was 0.30 ± 0.07. Mean RVFAC was 43.7 ± 5.21% and mean TAPSE was 1.79 ± 0.21 cm. There was no significant difference between preop and early postoperative TAPSE (P = 0.1010). The mean RVSP, maximum and mean gradient across the PV were 36.78 ± 8 mmHg, 23.58 ± 7.3 mmHg, and 10 ± 2.8 mmHg, respectively. Mean LVEF was 62.1 ± 4.2% and there was no significant residual lesion or valve regurgitation. The 6 min walk distance was 507.49 ± 36.7 m.

Follow-up

Functional status and electrocardiographic changes

Follow-up was 100% complete and the mean duration of follow-up was 53.3 ± 16.4 months. There was no mortality and no patient required reoperation or re-interventions during follow-up. At the last follow-up, 35 patients (94.6%) were NYHA Class I, and two patients (5.4%) were NYHA Class II [Table 4]. All the patients were in sinus rhythm without any atrial or ventricular ectopic and were leading an active life. The mean QRS duration was 106 ± 7.2 ms. Six-minute walk distance at the last follow-up was 506.67 ± 40.7 m.

Table 2: Operative characteristics of tetralogy of Fallot repair with pulmonary valve replacement patients

Variables	Value, *n* (%)
Cardiopulmonary bypass time (min)	154.4 ± 44.75
Aortic cross clamp time (min)	122.3 ± 37.73
Associated procedures	
Two patch AVCD repair	4 (10.8)
Aortic valve replacement	1 (2.7)
MAPCA ligation	5 (13.5)
LPA plasty	4 (10.8)
Branch pulmonary artery reduction	4 (10.8)
mBT shunt take down	3 (8.1)
OS-ASD closure	4 (10.8)
Size of pulmonary prosthesis (mm)	
19	3 (8.2)
21	16 (43.2)
23	12 (32.4)
25	6 (16.2)
Type of bioprosthesis	
Carpentier Edward perimount	1 (2.7)
St. Jude Epic	33 (89.1)
St. Jude Biocor	3 (8.2)
pRV/LV (%)	0.55 ± 0.10
RV-PA gradient (mmHg)	13.3 ± 5.7

AVCD: Atrio-ventricular canal defect, MAPCA: Major aorto-pulmonary collateral, LPA: Left pulmonary artery, mBT: modified Blalock Taussig, OS-ASD: Ostium secundum atrial septal defect, pRV/LV: right ventricle/left ventricle pressure ratio, RV-PA: Right ventricle to pulmonary artery

Table 3: Postoperative and follow-up parameters in tetralogy of Fallot repair with pulmonary valve replacement patients

Variables	Value, *n* (%)
Duration of mechanical ventilation (h)	10.37±6.2
Duration of ICU stay (days)	3.5±0.9
Vasopressor inotrope score (*n*)	13.16±3.32
Central venous pressure (mmHg)	7±2.1
RVEDP (mmHg)	8.5±3.4
Postoperative SpO_2 (%)	96.8±2.4
Postoperative complications	
Re-intubation	2 (5.4)
Re-exploration	2 (5.4)
Pleural effusions	2 (5.4)
LCOS	0
Acute renal failure	0
Sepsis	0
Arrhythmia	0
Perioperative mortality (*n*)	0
Hospital stay (days)	8.4±2.3
Follow-up data	
Duration of follow-up (months)	41.3±10.4
Re-operation/re-intervention	0
Late mortality	0

ICU: Intensive care unit, SpO_2: Oxygen saturation, LCOS: Low cardiac output syndrome, RVEDP: Right ventricular end diastolic pressure

Compared to preoperative status, there was a significant improvement in the NYHA class ($P < 0.001$) [Table 4]. In ECG, mean QRS duration increased significantly early after surgery and remained increased during follow-up ($P < 0.0001$). However, compared to QRS duration at discharge, it did not change significantly during follow-up (103 ± 6.7 vs. 106 ± 7.2; $P = 0.067$) [Figure 1]. Six-minute walk distance did not change significantly during follow-up ($P = 0.64$).

Echocardiography parameters during follow-up

At the last follow-up, the mean LVEF was 65.1 ± 6.0%. Mean RVEDA and mean RVESA were 14.1 ± 0.9 cm^2 and 8.78 ± 1.22 cm^2, respectively. RVMPI was 0.31 ± 0.09. Mean RVFAC was 45.3 ± 4.52% and mean TAPSE was 1.84 ± 0.26 cm. None of these parameters changed significantly during follow-up [Table 5]. The mean RVSP, maximum and mean gradient across the PV were 39.73 ± 8.5 mmHg, 26.58 ± 7.3 mmHg, and 11 ± 3.8 mmHg, respectively. There was no significant increase in any of these parameters. Two patients (5.4%) developed moderate PR and two patients (5.4%) developed moderate PS during follow-up. No patient had any significant residual shunt or valve regurgitation.

On comparing the patients aged <17 years ($n = 15$) and >17 years ($n = 22$) at the time of surgery, incidence of bioprosthetic valve dysfunction was more in patients aged <17 years (20%) compared to patients aged ≥17 years (4.5%). However, the difference was not statistically significant. ($P = 0.13$)

DISCUSSION

Numerous studies in the last 40 years have reiterated that TOF repair with competent PV not only results in the smooth perioperative course but also better long-term

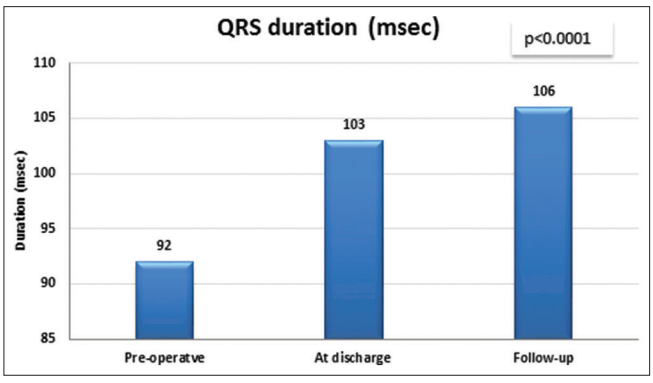

Figure 1: Change in QRS duration in the study population at discharge and during follow-up

Table 4: Change in functional class at discharge and during follow-up in tetralogy of Fallot repair with pulmonary valve replacement patients

Variables	Preoperative, *n* (%)	At discharge, *n* (%)	Follow-up, *n* (%)	*P*
Functional class				
NYHA-I	2 (5.4)	-	35 (94.5)	<0.0001
NYHA-II	13 (35.1)	-	2 (5.4)	0.0014
NYHA-III	19 (51.3)	-	-	<0.0001
NYHA-IV	3 (8.1)	-	-	0.0077
6 min walk test (m)	-	507.49±36.7	506.67±40.7	0.92

NYHA: New York heart association

Table 5: Comparison of echocardiography parameters early after surgery and during follow-up in tetralogy of Fallot repair with pulmonary valve replacement patients

Variables	Early postoperative	Follow-up	*P*
RVEDA (cm^2)	13.7±1.2	14.1±0.9	0.11
RVESA (cm^2)	8.53±1.13	8.78±1.22	0.29
RVMPI	0.30±0.07	0.31±0.09	0.59
RVFAC (%)	43.7±5.21	45.3±4.52	0.16
TAPSE (cm)	1.79±0.21	1.84±0.26	0.37
RVSP (mmHg)	36.78±8	39.73±8.5	0.12
PV Gmax (mmHg)	23.58±7.3	26.58±7.3	0.08
PV Gmean (mmHg)	10±2.8	11±3.8	0.20
LVEF	62.1±4.2%	65.1±6.0%	0.01
Significant residual shunt, *n* (%)	0	0	-
Mild TR	9 (24.3)	10 (27)	0.79
Mild PR	8 (21.6)	8 (21.6)	1.00
Moderate PR	0	2 (5.4)	0.15
Severe PR	0	0	-
Moderate PS	0	2 (5.4)	0.15
Severe PS	0	0	-
Mild MR	2 (5.4)	2 (5.4)	1.00
Moderate MR	0	1 (2.7)	0.31

RV: Right ventricular, RVEDA: RV end diastolic area, RVESA: RV end systolic area, RVSP: RV systolic pressure, RVMPI: RV myocardial perfusion index, RVFAC: RV fractional area change, MPI: Myocardial perfusion index, FAC: Fractional area change, TAPSE: Tricuspid annular plane systolic excursion, PV: Pulmonary valve, Gmax-Maximum gradient, Gmean: Mean gradient, LVEF: Left ventricle ejection fraction, TR: Tricuspid regurgitation, PR: Pulmonary regurgitation, MR: Mitral regurgitation, PS: Pulmonic stenosis

outcome in terms of ventricular function, symptoms, and survival.[15-17] Our results also reaffirm that TOF repair with concomitant PVR can be safely performed in adolescent and adult patients without mortality and good outcome at midterm without significant valvular degeneration. All our patients remained clinically asymptomatic with preserved exercise capacity, RV contractility, and dimensions at mid-term.

Why concomitant pulmonary valve replacement in adolescent and adult patients with tetralogy of Fallot?

After the insertion of TAP, RVOT becomes akinetic or dyskinetic along with variable severity of PR. This results in reduced effective forward flow, increased RVESV and the development of subclinical RV diastolic dysfunction long before the patients become symptomatic.[18] Gradually, patients develop symptoms of congestive heart failure with reduced exercise capacity, ventricular and supraventricular arrhythmias, and increased risk of sudden cardiac death.[19] PVR in these patients after the development of complications results in only limited improvement in their ventricular function, QRS duration, and clinical symptoms.[10] Studies have also found that PVR done more than 2 years after the TAP may fail to reverse RV dysfunction and exercise performance to normal.[20] These observations highlight the importance of achieving a competent PV at the initial TOF repair in adults. We believe that PVR not only establishes the competency of PV but, also creates a neo-pulmonary annulus mitigating the RVOT patch-related dysfunction.

Early and mid-term outcome of tetralogy of Fallot repair with pulmonary valve replacement in adult patients

Perioperative morbidity and mortality

In our study, no patient developed LCOS, arrhythmias, ARF or ventricular dysfunction. Vasopressor inotropic score was low and 80% of patients were extubated within 12 h of surgery. Postrepair, mean CVP was 7 ± 2.1 mmHg and mean RVEDP was 8.5 ± 3.4 mmHg suggesting the absence of RV dysfunction despite the presence of severe RV hypertrophy. The incidence of pleural effusion and re-intubation was 5.4% which is comparable to other studies.[1,17] Operative mortality for TOF repair in adults is higher (4%–8%) compared to pediatric patients (<1%).[1] Studies have cited previous palliation and older age at repair (>40 years) as important risk factors for perioperative mortality.[1] In our series, there was no operative mortality. We believe that relatively younger age (mean 18.48 years) of our patients and low incidence of previous palliation (11%) were the major contributory factor for zero mortality in our series. We are not sure whether the protective effect of competent pulmonary valve on RV function had any role in good outcome in our series.

Functional improvement

The myocardium in adult patients with TOF is usually jeopardized due to prolonged hypoxia, polycythemia and severe hypertrophy. Any amount of PR, pulmonary stenosis or other residual lesions further worsen their ventricular function.[1,18-20] Complete repair without residual lesion and competent PV can circumvent many deleterious effects on already compromised myocardium

and improve the functional outcome. In our study, functional outcome was excellent with all the patients in NYHA Class I or II at follow-up of 53.3 ± 16.4 months. We attribute our excellent results to the younger age of the patients and the absence of PR or residual lesions. Similar results are reported by Patel *et al*.[17] and Waien *et al*.[21] In the prospective observational study by Patel *et al*., 235 patients with TOF who underwent trans-right atrial repair and had minimal or mild PR in the postoperative period; patients had near-normal VO_2 max at mean follow-up of 6.10 ± 1.86 years.

Arrhythmias, sudden death and long-term survival

Patients operated for TOF are at increased risk of arrhythmias and sudden death. Although, atrial fibrillation is the most frequent arrhythmia; ventricular tachycardia (VT) is the most common cause of sudden death and is attributed to the prolongation of QRS duration. QRS duration >180 ms predisposes the patient to the risk of VT and once a patient develops VT, PVR does not reduce the incidence of sudden death.[1,7,12,22] Apart from QRS duration, reduction in LVEF is also an important risk factor for survival after PVR. In a study done by Tobler *et al*., they found that QRS duration >180 ms combined with the reduction in LVEF had the highest positive predictive value for sudden cardiac death.[23] These findings were further substantiated by the meta-analysis done by Ferraz Cavalcant *et al*. The authors concluded in their meta-analysis that reduction of QRS duration and improvement in LVEF after PVR in combination might mean reduction in long-term mortality.[10] Therefore, PVR should be done after TOF repair sooner than later before the patient develops the irreversible changes in QRS duration and LVEF. A study by Harrild *et al*. found that after PVR, QRS duration tends to stabilize only when pre-PVR QRS duration <150 ms while, it continues to progress if pre-PVR QRS duration >160 ms.[12] All these observations substantiate that any duration of PR has deleterious effect on the myocardium. Therefore, we believe that whenever possible, primary prevention of PR is better than its treatment at a later stage to mitigate the long-term complications. Our results confirm the same. At mid-term follow-up, all our patients remained in sinus rhythm with mean QRS duration of 106 ± 7.2 ms and there was no evidence of atrial or ventricular arrhythmia in ECG. We, however, did not perform Holter monitoring in any patient to confirm the same.

Only 24%–73% of patients who undergo TOF repair in adulthood survive for 10 years.[1] In our series, survival was 100% at mid-term. We believe that it is due to the younger age of our patients, preserved ventricular function, and shorter duration of follow-up. We need a longer duration of follow-up to determine whether concomitant TOF repair and PVR results in improved long-term survival considering that all our patients are at risk for bioprosthetic valve degeneration and may require repeated surgeries for PV in future.[1,24]

Choice of pulmonary prosthesis

The bioprosthetic valve is the prosthesis of choice at the pulmonary position. It has many advantages (1) It is easy to implant, functions reliably, and does not require prolonged systemic anticoagulation. (2) Maintains the continuity between RV and branch pulmonary arteries by native tissue hence less risk of calcification. (3) Ease of percutaneous valve-in-valve implantation. (4) Ease of percutaneous intervention for the pulmonary arterial tree. (5) Prosthesis of choice in patients with significant RV dysfunction or congestive heart failure.

Although, recent study with the limited number of patients has shown comparable results with mechanical prosthesis at the pulmonary position with acceptable thrombotic and hemorrhagic complications;[25] still, mechanical prosthesis at pulmonary position requires robust systemic anticoagulation and it is reserved for the patients who have mechanical prosthesis at any other position or have any associated condition warranting anticoagulation.

Bioprosthetic valve degeneration

In our institute, we prefer stented bioprosthesis for PVR. Studies have uniformly reported better long-term durability of the stented bioprosthetic valve over homograft or Dacron porcine-valved conduit.[26] However, amongst stented bioprosthetic valves, studies have consistently failed to establish the superiority of the pericardial valve over the porcine valve or vice versa in terms of valve degeneration and improved survival.[27,28] In this study, at the mean follow-up of 53.3 ± 16.4 months, 4(10.8%) patients developed bioprosthetic valve degeneration. However, we did not compare the different valve types due to the limited number of patients.

Regarding bioprosthetic valve degeneration based on age, our results are in congruence with previous studies.[28,29] Similar to the previous study, we also found that valve degeneration was more frequent in younger patients (20% v/s. 4.5% in patients aged <17 years and ≥17 years, respectively). The difference, however, did not reach the statistically significant level due to the limited number of patients and shorter duration of follow-up.

Limitations of the study

Our study has many limitations. First, ours is a retrospective study with a small sample size. Second, there is no control arm of adult patients with TAP to compare the difference in the result. Third, we have not used cardiac magnetic resonance imaging which

is a better modality to assess RV size and function. Fourth, we had not performed 24-h Holter monitoring to record subclinical arrhythmias. Fifth, short duration of follow-up. Therefore, we recommend studies involving a larger number of patients in both the arms and longer duration of follow-up.

CONCLUSIONS

In adult patients with TOF and HPA, concomitant PVR with TOF repair can be safely performed without the increased risk of mortality, acceptable rate of PV degeneration, and excellent outcome at mid-term. PVR not only eases the perioperative course but, preserves the ventricular function as well as functional status of the patient during follow-up.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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