Cardiology in the Young

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Original Article

Cite this article: Minh DT, Huu UN, Tuan BL, Tuan MN, Dinh DM, Quang VT, Hong QL, St. Louis J, and Ly Thinh TN (2024) Effectiveness of pulmonary valve-sparing strategy for transatrial-transpulmonary repair of tetralogy of Fallot: a single institution experience. *Cardiology in the Young* **34**: 1662–1669. doi: 10.1017/S1047951124000441

Received: 10 January 2024
Revised: 19 February 2024
Accepted: 20 February 2024
First published online: 12 April 2024

Keywords:
mini-transannular patch; tetralogy of Fallot; transatrial-transpulmonary repair; valve-sparing strategy

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Effectiveness of pulmonary valve-sparing strategy for transatrial-transpulmonary repair of tetralogy of Fallot: a single institution experience

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Abstract

Objective: We report the midterm results of our strategy utilizing transatrial-transpulmonary repair for tetralogy of Fallot at a single institution in a low-middle income country. *Methods:* Medical records were retrospectively reviewed for 532 consecutive patients who underwent definitive repair of tetralogy of Fallot at our institution from 2010 to 2020. *Results:* The median age and weight of patients in the study patients were 11.6 months (interquartile range, 8.6–17.2 months) and 7.5 kg (interquartile range, 6.8-8.8 kg). The pulmonary valve annulus was preserved (no transannular patch) in 398 patients (75%) and a mini-transannular patch was utilized for 134 patients (25%). The overall survival was 98% at 1 year, and 97% at 10-years follow-up, respectively. Longer postoperative ventilation time was the only risk factor correlated to early death ($p = 0.004$; Odds Risk, 1.04; 95% confidence intervals, 1.01–1.07). Fourteen patients required pulmonary valve replacement (2.6%, 14/532), four required surgical resection to relieve right ventricular outflow tract obstruction (0.8%, 4/532), and freedom from reoperation of the right ventricular outflow tract was 87% at 10 years. The only risk factor for right ventricular outflow tract reoperation was a postoperative systolic pressure gradient through the right ventricular outflow tract of greater than 50 mmHg ($p < 0.001$; HR, 47; 95% confidence intervals, 9.1–244). In total, 94.6% (471/489) of the patients were asymptomatic at the latest follow-up without significant arrhythmia. *Conclusion:* At our institution in an low-middle income country, the transatrial-transpulmonary repair for tetralogy of Fallot has excellent midterm results with few reoperations required. Close long-term follow-up is essential for patients who undergo repair with a mini-transannular patch and may eventually require pulmonary valve replacement.

It has been almost 70 years since the initial repair of tetralogy of Fallot was performed by Lillehei and colleagues.[1] Survival after definitive tetralogy of Fallot repair is excellent with less than 3% mortality being reported in industrialised countries.[2–9] Transatrial-transpulmonary repair of tetralogy of Fallot has gained popularity over the past two decades as a result of the haemodynamic advantage of maintaining the integrity of the pulmonary valve annulus and the right ventricular infundibulum. This approach can help to reduce the incidence of pulmonary regurgitation, as well as the potential to minimise dilatation of the right ventricular and reduce the frequency of reintervention/replacement of the pulmonary valve in the right ventricular outflow tract on the long-term outcome of tetralogy of Fallot.[10] For families with children who have CHD in a low-middle income country, especially those who may require additional cardiac surgery due to the need for reoperation for pulmonary valve replacement, this additional surgery can represent a significant economic burden on the family and a barrier for optimal care of their child. Furthermore, long-term follow-up may be challenging, particularly for rural residents and members of minority groups, whose potential lack of close follow-up may put them at high risk of sudden death from right heart failure or a fatal arrhythmia secondary to severe ongoing pulmonary valve regurgitation. Thus, at our institution, we chose to defer neonatal tetralogy of Fallot repair and routinely performed transatrial-transpulmonary to reduce reoperation rates and postoperative complications. Our study objective is to assess the midterm results of our 532 tetralogy of Fallot patients who received complete repair utilising the transatrial-transpulmonary technique for overall mortality and need for reoperation.

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Material and methods

Patients

From December 2010 to December 2020, we retrospectively reviewed the medical records of all tetralogy of Fallot patients and identified 532 consecutive patients (316 males, 216 females) who underwent definitive repair for tetralogy of Fallot using the transatrial-transpulmonary technique at Vietnam National Children's Hospital. This study included patients diagnosed with classic tetralogy of Fallot: a large outlet subaortic ventricular septal defect, with marked anterior and leftward displacement of the infundibular septum resulting in obstruction of the right ventricular outflow tract. Patients diagnosed with absent pulmonary valve syndrome, pulmonary atresia, double outlet right ventricle Fallot type, and tetralogy of Fallot associated with atrioventricular septal defect were excluded from this study. Patient informed consent has been waived according to our National Legislation and Institutional Requirements. The study was approved by the Ethics Committee of the Hospital (Ref. number: 887/BVNTW-VNCSKTE). At our institution, our protocol is to utilise a modified Blalock-Taussig shunt in a symptomatic infant or neonate under three months old, and definitive repair is considered 6 months after the palliative Blalock-Taussig shunt procedure. In children greater than six months but less than one year, our protocol is to perform primary tetralogy of Fallot repair. All study patients underwent echocardiography, cardiac catheterisation, or multiple-slide CT prior to definitive surgery. Our protocol for preoperative multiple-slide CT was described as follows: After clinical examination and echocardiogram were performed, any patients suspected to have collaterals origin from descending aorta on echocardiogram or unjustified high saturation will be indicated cardiac catheterisation to evaluate and eliminate the collaterals before definitive repair. If the echocardiogram did not show any evidence of collaterals and the saturation was normal range, the 256-slice will be indicated to further examine the intracardiac anatomy and detect any small collaterals if possible.

Following definitive repair, patients were serially followed at the outpatient clinic of our institution with clinical examination, chest X-ray, electrocardiogram, and echocardiography at 1 month, 3 months, 6 months, and annually after the operation, including telephone check-ups. When a clinical problem was suspected and the echocardiogram imaging was undiagnostic, cardiac catheterisation and 256-slice CT were performed. Reoperation was indicated to release right ventricular outflow tract obstruction when a max pressure gradient across the right ventricular outflow tract of more than 60 mmHg, or pulmonary valve replacement when symptomatic patients with exercise intolerance associated with symptoms of heart failure or syncope related to arrhythmia, or when asymptomatic patients with right ventricular end-diastolic volume index > 150ml/m^2, and QRS duration > 160 ms.[11]

All follow-up data on the available transatrial-transpulmonary tetralogy of Fallot repair patients were also collected for this study and a final clinical follow-up was made with the patient's parents by phone.

The median age and weight of patients in our study were 11.6 months [interquartile range, 8.6–17.2 months] and 7.5 kg (interquartile range, 6.8–8.8 kg), respectively. In the less than three months-old group, one patient underwent stenting of the patent ductus arteriosus, and 45 patients underwent a Blalock-Taussig shunt as a palliative procedure before a definitive tetralogy of Fallot repair was performed. Of these 45 patients, 38 underwent a Blalock-Taussig shunt via lateral thoracotomy and seven had their Blalock-Taussig shunt placed through a midline sternotomy. After definitive repair of tetralogy of Fallot, 95.6% of patients (498 of 521 survival patients) completed follow-up with a median follow-up of 4.6 years (interquartile range, 2.9–6.1 years).

Surgical techniques

All patients in our study underwent a uniform operating protocol using standard cardiopulmonary bypass with bicaval cannulation and cooling to a core temperature of 28°C. If the patient had a previous Blalock-Taussig shunt in place, before the start of cardiopulmonary bypass, the shunt was dissected out and divided in all cases. A meticulous dissection of the main pulmonary artery and both pulmonary artery branches was performed, and any visually stenotic sites underwent concurrent repair at the same time as the complete tetralogy of Fallot repair. Cardioplegia arrest was introduced via the ascending aorta after aortic cross-clamp with Custodiol® solution. The right atrium was opened and the ventricular septal defect was always closed through the tricuspid valve using interrupted 5.0–6.0 polypropylene pledgeted sutures with bovine pericardial patch. After ventricular septal defect closure, the parietal and septal extensions of the infundibular septum were divided and excised parallel to the aortic annulus up to the level of pulmonary valve annulus until the pulmonary valve can be clearly visualised. To facilitate greater anterior wall movement of the infundibulum and provide a broader right ventricular outflow tract, the anterior infundibulum trabeculations are also excised. The pulmonary trunk was opened longitudinally from the main pulmonary artery down to the pulmonary sinus, with particular care taken to avoid crossing the anterior commissure of the pulmonary valve. Fusion of the pulmonary valve commissures was detached from the pulmonary artery wall and commissurotomy was performed. The right ventricular outflow tract anatomy underwent further inspection to excise any remaining obstruction caused by the superior portion of the parietal and septal extensions. To fully eliminate any obstructions of the right ventricular outflow tract, a fibrous ring often seen encircled the area of the right ventricular outflow tract just below the pulmonary valve was then completely excised if present (pulmonary valve preserved group).

A Hegar dilator was then introduced into the right ventricular outflow tract and if the Hegar dilator was not able to be easily pass in the right ventricular outflow tract, a mini-transannular patch extending from the pulmonary incision up to the infundibulum was performed with restriction of less than 1.5 cm if the measured pulmonary annulus' Z-score was −2 or lesser (mini transannular patch group). A monocusp valve using Polytetrafluoroethylene 0.1 mm was placed, or a fresh autologous pericardium patch was used to simply cover the opening of the pulmonary trunk and the infundibulotomy. If pulmonary artery branch stenosis was present, it was simultaneously treated with a different autologous pericardial patch. Tricuspid valve's functionality was then checked by saline testing, and if moderate or greater tricuspid regurgitation was found, the valve was repaired by commissuroplasty between the septal and the anterior leaflet. The patent foramen ovale was left open in all patients in our study.

Immediately after weaning off bypass, an right ventricular/left ventricular pressure ratio was directly measured in all patients. If the patient's pulmonary valve annulus required a mini-transannular patch, a calculated pressure ratio of less than 0.8 was acceptable, and a pressure ratio of less than 0.75 was

https://doi.org/10.1017/S1047951124000441 Published online by Cambridge University Press

acceptable if the patient's pulmonary valve annulus was preserved. Recently, epicardial or transesophageal echocardiography has been performed to evaluate the intracardiac anatomic repair, ventricular function, and any significant residual haemodynamic lesions such as a significant right ventricular outflow tract obstruction, severe tricuspid regurgitation, branch stenosis, or a residual ventricular septal defect larger than 3 mm. Any significant residual lesion found led to the reinstitution of cardiopulmonary bypass with a second aortic cross-clamp and cardioplegia arrest was utilised if needed to repair the residual lesion. If the repair was found acceptable, the patient was then transferred to the cardiovascular ICU.

Statistical analysis

Categorical variables are presented as percentages. Continuous variables are described by median with interquartile range for skewed data and mean with standard deviation for variables that have normal distribution. Multivariate logistic regression analysis was performed to determine risk factors for early mortality. Cox regression multivariate analysis was performed to identify risk factors for reoperation. Univariable analysis identified variables with p value less than 0.1 that were entered into a stepwise multivariable logistic regression model or multivariate Cox analysis to determine the independent predictor of outcomes. The odd ratio or hazard ratio with a 95% confidence interval is reported for statistical analysis. A p value of less than 0.05 was set for the level of statistical significance. The Kaplan-Meier method describes the overall survival and freedom of reoperation. All statistical analyses were performed with IBM SPSS Statistics 20 (IBM Corp, Armonk, NY).

Results

The pulmonary valve annulus was preserved in 398 pulmonary valve preserved patients (75%) and a mini-transannular patch was utilised in 134 mini transannular patch patients (25%) during the study period. The median age and weight were not different between the two groups. However, the pulmonary valve preserved group tended to have higher oxygen saturations ($p = 0.029$), and more favourable surgical anatomy (higher incidence of tricuspid pulmonary valve, larger pulmonary valve annulus, and higher Nakata index of pulmonary artery, all $p < 0.05$) as compared to the mini transannular patch group. Patient characteristics are described in Table 1.

Early outcomes

The aortic cross-clamp time ($p < 0.001$) and bypass time ($p < 0.001$) were both lower in the pulmonary valve preservedgroup. The measured intraoperative right ventricular/left ventricular pressure ratio was lower in the pulmonary valve preserved group ($p < 0.001$), and postoperative ventilation time was significantly lesser in the pulmonary valve preserved group. Low cardiac output syndrome was significantly higher in the mini transannular patch group as compared to the pulmonary valve preserved patient group. The perioperative patient characteristics are described in Table 2.

There were 11 in-hospital deaths (2.1%, 11/532), including five patients who developed severe right ventricular failure associated with multi-organ failure secondary sepsis or septic shock. Four other patients developed critical arrhythmia incessant junctional ectopic tachycardia leading to severe low cardiac output syndrome. The final two patients had undetected large muscular ventricular septal defect preoperatively, which required reoperation for ventricular septal defect closure but developed severe low cardiac output syndrome after reoperation. There were two late deaths during follow-up. The first patient had trisomy 21 and died 33 months after complete repair with pneumonia at the province hospital. The second who presented preoperatively with significantly low World Health Organization weight/body mass index-for-age percentile also died of pneumonia at 54 months after complete repair. The overall survival after transatrial-transpulmonary repair for tetralogy of Fallot in this study was 98% at 1 year, and 97% at 5- and 10-year follow-up, respectively (Fig. 1).

Logistic univariate analysis for in-hospital mortality revealed sepsis ($p < 0.001$; Odds Risk, 15.1; 95% confidence intervals, 4.07–56.02), acute kidney insufficiency ($p < 0.001$; Odds Risk, 107.14; 96% confidence intervals, 1.78–527.07), low cardiac output syndrome ($p < 0.001$; Odds Risk, 79.83; 95% confidence intervals, 10.04–634.95), critical postoperative arrhythmia ($p = 0.01$; Odds Risk, 4.66; 95% confidence intervals, 1.39–15.65), acute liver failure ($p < 0.001$; Odds Risk, 89.96; 95% confidence intervals, 21.68–373.2), pleural effusion ($p = 0.001$; Odds Risk, 13; 95% confidence intervals, 2.77–60.91), and need for longer postoperative ventilation ($p < 0.001$; Odds Risk, 1.04; 95% confidence intervals, 1.03–1.06). In logistic multivariate analysis, only longer postoperative ventilation time significantly affected early mortality ($p = 0.004$; Odds Risk, 1.04; 95% confidence intervals, 1.01–1,07) in this study.

Late outcomes

Of the 521 survivors in our study, thirty-two patients (6.1%, 32/521) were lost to follow-up leaving 489 patients available for long-term evaluation. Echocardiographic results from their latest follow-up visits showed that, overall, 176 patients (36%, 176/489) had greater than moderate pulmonary valve regurgitation, and two patients (0.4%, 2/489) had greater than moderate tricuspid valve regurgitation. Conversely, there are significantly fewer pulmonary valve preserved patients ($p < 0.001$) with more than moderate pulmonary valve insufficiency compared to the mini transannular patch group. Patients in the pulmonary valve preserved group also have significantly less mild or moderate tricuspid valve regurgitation ($p = 0.02$; $p = 0.04$, respectively) as compared with mini transannular patch group. Finally, by echocardiography, the mean pressure gradient across the right ventricular outflow tract was 17,9 ± 10,05 mmHg. The details of these patients' follow-up functional status by echocardiography are described in Table 3.

During the follow-up period, a total of 24 patients (4.5%, 24/532) required 24 reoperations and four interventions including: surgical pulmonary valve replacement ($n = 14$), relief of right ventricular outflow tract obstruction ($n = 4$), pacemaker implantation for complete heart block ($n = 6$), left pulmonary artery balloon dilatation due to LPA stenosis ($n = 4$), concomitant left pulmonary artery arterioplasty with pulmonary valve replacement ($n = 3$), concomitant closure of residual ventricular septal defect with pulmonary valve replacement ($n = 1$), and concomitant aortic valve repair with pulmonary valve replacement ($n = 1$). The overall freedom for right ventricular outflow tract reoperation was 99, 96, and 87% at 1 year, 5 years, and 10 years, respectively. The freedom for right ventricular outflow tract reoperation in the pulmonary valve preserved group was 99, 98, and 91% at 1, 5, and 10 years compared with 99, 89, and 77% in the mini transannular patch group (Fig. 2).

https://doi.org/10.1017/S1047951124000441 Published online by Cambridge University Press

Table 1. Patients characteristics

Patient's characteristics	Overall (n = 532)	MTP group (n = 134)	PVP group (n = 398)	p value
Age (month)	11,77 (8,78–17,37)	11,97 (8,85–18,3)	11,7 (8,7–16,9)	0.66 (t test)
Weight (kg)	7,5 (6,83–8,8)	7,6 (7–8,9)	7,5 (6,8–8,8)	0.49 (t test)
Previous surgery				
BT shunt	8,5% (n = 45)	12,1% (n = 16)	7,3% (n = 29)	0.13 (Z test)
Melbourne shunt	0,2% (n = 1)	0	0,3% (n = 1)	1 (F test)
Associated lesions				
m-VSD	0,4% (n = 2)	0,8% (n = 1)	0,3% (n = 1)	0.44 (F test)
Oxygenation (%)	84,96 ± 8,99	83 ± 8,9	85,54 ± 9,18	0.029 (t test)
PV anatomy				
Bicuspid	87,4% (n = 465)	94,7% (n = 127)	85% (n = 338)	0.0098 (Z test)
Tricuspid	12,6% (n = 67)	5,3% (n = 7)	15% (n = 60)	0.0047 (Z test)
PV annulus diameter (mm)	9 (8–10,5)	7 (6–8)	10 (9–11)	<0.001 (t test)
PV Z-score	−1,04 (−1,99; −0,08)	−2,64 (−3,69; −2,02)	−0,68 (−1,41;0,03)	<0.001 (t test)
Nakata index	252 (199–333)	234 (188–278)	258 (204–345)	0.02 (t test)

BT shunt = Blalock-Taussig shunt; m-VSD = muscular ventricular septal defect; MTP = mini transannular patch; PVP = pulmonary valve preserved.

Table 2. Perioperative variables

Intraoperative variables	Overall (n = 532)	MTP group (n = 134)	PVP group (n = 398)	p value
Aortic cross-clamp (minutes)	113,94 ± 32,57	127,17 ± 35,31	109,53 ± 30,39	< 0.001 (t test)
	(36–304)	(57–242)	(36–304)	
Bypass time (minutes)	144,08 ± 41,02	163,5 ± 45	137,76 ± 37,59	< 0.001 (t test)
	(62–363)	(79–311)	(62–363)	
Ventilation time (hours)	35 (21–68)	60.5 (29.2–110)	30.4 (20.0–51.1)	<0.001 (t test)
RV/LV ratio	50,53 ± 11,82	53,92 ± 12,23	49,39 ± 11,47	< 0.001 (t test)
	(21–80)	(27–75)	(21–80)	
LCOS	12,8% (n = 68)	23,3% (n = 31)	9,3% (n = 37)	<0.001 (F test)
Peritoneal dialysis	5,6% (n = 30)	12% (n = 16)	3,5% (n = 14)	<0.001 (F test)
Liver failure	4,3% (n = 23)	9% (n = 12)	2,8% (n = 11)	<0.022 (F test)
Arrhythmia	15,8% (n = 84)	24,6% (n = 33)	12,8% (n = 51)	0.001 (F test)
ECMO	0,2% (n = 1)	0,8% (n = 1)	0	0.25 (F test)
In-hospital death	2.1% (n = 11)	3% (n = 4)	1.8% (n = 7)	0.49 (F test)
Late death	0.4% (n = 2)	0	0.5% (n = 2)	1 (F test)

ECMO = extracorporeal membrane oxygenation; LCOS = low cardiac output syndrome; LV = left ventricle; MTP = mini transannular patch; PVP = pulmonary valve preserved.

Cox univariate analysis for risk factors of reoperation identified an echocardiography peak pressure gradient across the right ventricular outflow tract of more than 50 mmHg before patients discharge ($p < 0.001$; HR, 25.6; 95% confidence intervals, 8.4–78), a negative Z-score of pulmonary valve annulus ($p = 0.02$; HR, 0.7; 95% confidence intervals, 0.57–0.95), and patients being in the pulmonary valve preserved group ($p = 0.003$; HR, 0.24; 95% confidence intervals, 0.10–0.62). Multivariate Cox analysis showed the peak pressure gradient across the right ventricular outflow tract > 50 mmHg in echocardiography before discharge was the only risk factor for reoperation ($p < 0.001$; HR, 47; 95% confidence intervals, 9.1–244).

Discussion

While reports from high-income countries show excellent survival and outcomes after repair of tetralogy of Fallot with mortality approaching 0%,[7–9] a multicenter study from the International Quality Improvement Collaborative for Congenital Heart Disease Database reported the in-hospital mortality from developing countries of 3.6% with risk factors for death after definitive tetralogy of Fallot repair being postoperative oxygen saturation less than 90% and weight/body mass index for age below the fifth percentage.[12,13] The in-hospital mortality and overall mortality in our study (2.1% and 0.4%, respectively) are comparable with

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Table 3. Follow-up functional status by echocardiography

Follow-up data	Overall (n = 489)	MTP group (n = 117)	PVP group (n = 372)	p value
PV regurgitation				
Mild	26,2% (n = 128)	15,4% (n = 18)	29,6% (n = 110)	0.0021 (F test)
Moderate	37,8% (n = 185)	28,7% (n = 33)	40,8% (n = 152)	0.014 (F test)
Severe	36% (n = 176)	56,4% (n = 66)	29,6% (n = 110)	<0.001 (F test)
TV regurgitation				
Mild	95,7% (n = 468)	92,1% (n = 108)	97,1% (n = 360)	0.02 (F test)
Moderate	4,3% (n = 21)	7,7% (n = 9)	3.2% (n = 12)	0.047 (F test)
Severe	0	0	0	
RVOT pressure gradient (mmHg)	17.9 ± 10.05	16.8 ± 12.9	18.5 ± 10.7	0.17 (t test)
PVR or conduit reimplantation	2.8% (n = 14)	6.8% (n = 8)	1.6% (n = 6)	0.4172 (F test)
RPA stenosis reoperation	0	0	0	
LPA stenosis reoperation	0.4% (n = 2)	0	0.5% (n = 2)	1 (F test)
RVOTO reoperation	0.8% (n = 4)	0.85% (n = 1)	0.8% (n = 3)	1 (F test)
PA branch intervention	0.8% (n = 4)	2.6% (n = 3)	0.3% (n = 1)	0.051 (F test)

RPA = right pulmonary artery; PVR = pulmonary valve replacement; MTP = mini transannular patch; TV = tricuspid valve.

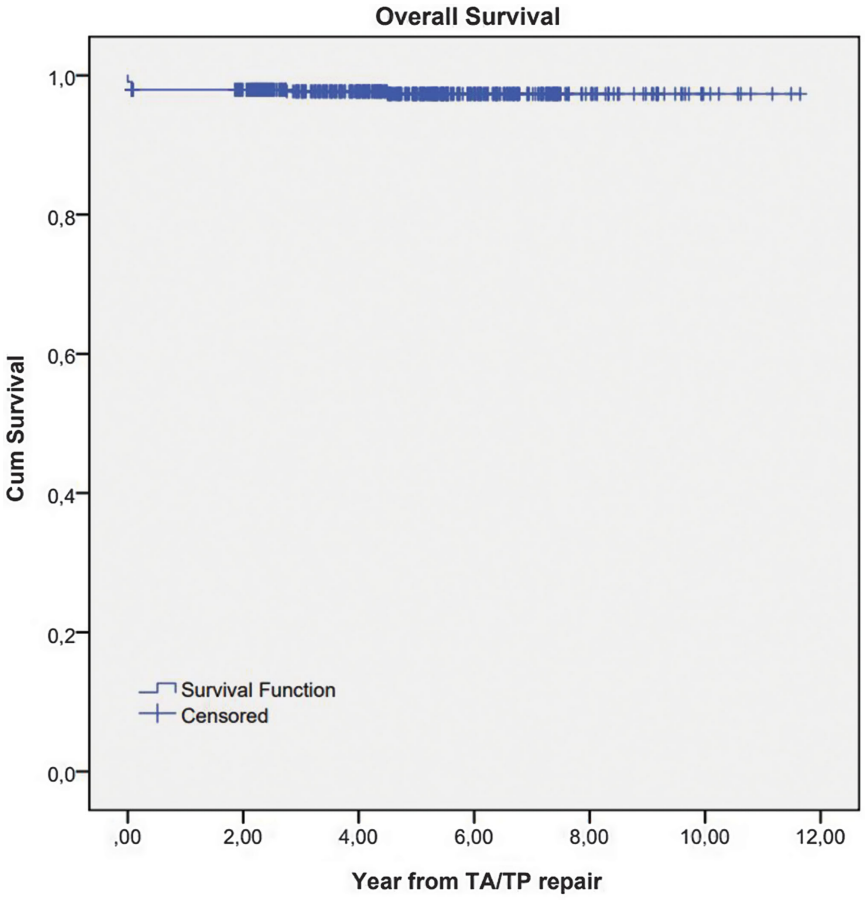

Figure 1. Overall survival after transatrial-transpulmonary repair for tetralogy of Fallot.

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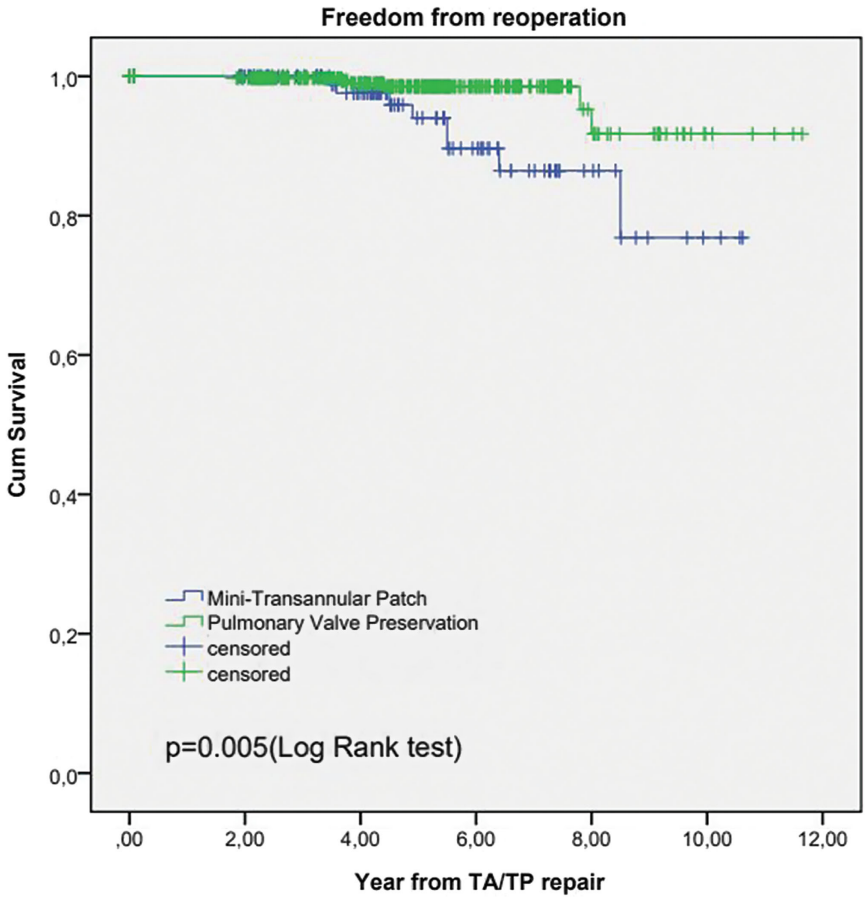

Figure 2. Freedom from reoperation between the pulmonary valve preserved group and mini transannular patch group.

previous studies using the transatrial-transpulmonary technique.[5,6,10] The need for longer postoperative ventilation was found to be a significant risk factor for in-hospital mortality in our series. With an in-hospital death rate of 2.1%, we hypothesised that by decreasing our postoperative ventilation times, our in-hospital mortality and morbidity might further decrease. After 2017, in our cardiovascular ICU, we discovered that limiting the peak airway pressure to less than 22 cm H2O and limiting the positive end-expiratory pressure range to between 3 and 4 cm H2O reduced the detrimental effect of mechanical ventilation on postoperative right ventricular function in our patients. Furthermore, additional factors such as the surgical method have not been modified, and intraoperative transesophageal echocardiography or preoperative CT scan have not been used at our institution, which is unlikely to have impacted on lowering in-hospital mortality during that period. Further knowing the effects of mechanical ventilation on postoperative right ventricular function, the use of mechanical ventilation was also minimised as much as appropriate, and 33.5% (178/532) of our patients were extubated within 24 hours following definitive surgery. Since then, our centre's in-hospital mortality rate following definitive tetralogy of Fallot repair is now approaching 0%.

Further, knowing the complications from long standing pulmonary valve regurgitation, which includes limited exercise tolerance, right ventricular dilatation, and eventual right ventricular failure, postoperative ventricular arrhythmia, and eventual requirement for pulmonary valve replacement, serious attempts were made intraoperatively to preserve the pulmonary valve annulus and pulmonary valve function in our centre. To maximise the chance of preserving pulmonary valve annulus and reduce the risk of pulmonary valve reintervention and reoperation for patients during their long-term follow-up, our centre's definitive tetralogy of Fallot repair strategy is specifically focused on the transatrial-transpulmonary approach, including deferring early neonatal definitive tetralogy of Fallot repair in favour of utilising Blalock-Taussig shunt palliation and delaying definitive tetralogy of Fallot surgical repair of up to 6 months of age. Further, because of the socio-economic conditions that exist in many low-middle income countries as well as the challenges faced by these patients' families to pay for repeated pulmonary valve replacement, we believe that our approach is more suitable in these circumstances.

d'Udekem and colleagues found that after 20 years of follow-up, only 15% of patients using transatrial-transpulmonary approach required a pulmonary valve replacement, in comparison to 30–40% of patients who received trans-ventricular repair.[6] In our study, we were successful in maintaining the pulmonary valve annulus in 75% of patients without using an infundibular patch (Fig. 3), which is contrary to previous studies[5–7] using the transatrial-transpulmonary technique, where fewer than 35% of patients were successful in maintaining their pulmonary valve annulus. The much greater incidence of pulmonary valve annulus preservation in our study leads us to believe that a smaller

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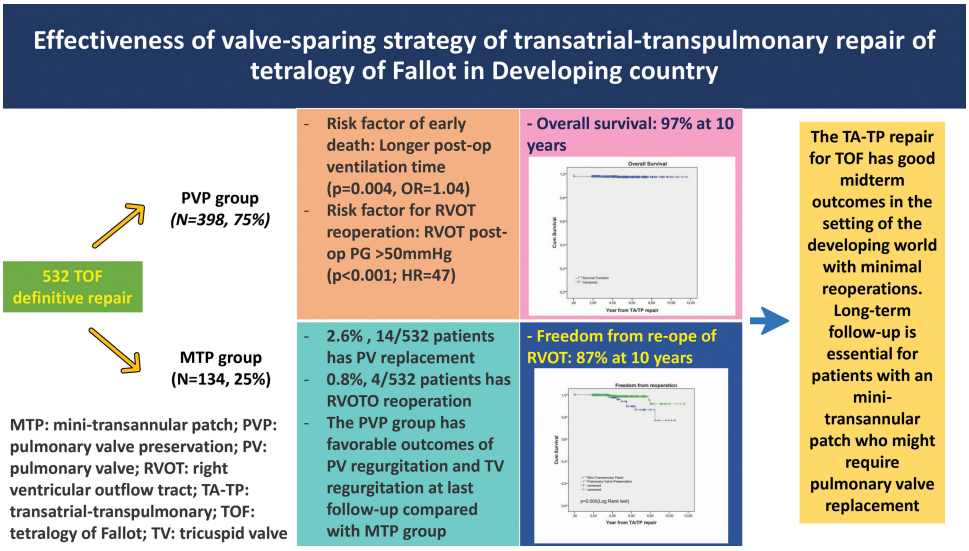

Figure 3. Effectiveness of valve-sparing strategy of transatrial-transpulmonary repair of tetralogy of Fallot in developing country.

percentage of our patients will need a second operation to replace the pulmonary valve in the future compared to the findings of the previously mentioned studies. We hypothesise that given our transatrial-transpulmonary technique, this percentage should not increase significantly in the future. Our study shows that 2.8% (14/532) of patients had their pulmonary valve replacement after 10 years of follow-up, providing further support to our hypothesis that transatrial-transpulmonary technique will result in less need for reduced pulmonary valve replacement. Our results are encouraging given our low pulmonary valve reoperation rate and also a low incidence of ventricular arrhythmia, but further research is required to accurately evaluate the effectiveness of potential protection from pulmonary valve replacement using the transatrial-transpulmonary technique.

Recent studies showed that patients who underwent valve-sparing or limited right ventriculotomy had higher survival rates, fewer cardiovascular reinterventions, less need for pulmonary valve replacements, greater exercise tolerance, and smaller right ventricular end-diastolic diameter Z scores compared to patients who underwent right ventriculotomy for the closure of the ventricular septal defect.[3,4,14,15] Notwithstanding the fact that the right ventriculotomy approach was not employed in our study to close the ventricular septal defect, our findings indicate that patients in the mini transannular patch group have more challenging postoperative courses, including longer ventilation times, a greater need for peritoneal dialysis, a higher ratio of liver failure, and a higher percentage of arrhythmia. However, the mortality between the pulmonary valve preserved group and the mini transannular patch group is comparable. By echocardiography assessment at last clinic visit of the surviving patients, the pulmonary valve preserved group exhibits a higher number of patients with mild or moderate pulmonary valve insufficiency and a significantly lower proportion of patients with severe pulmonary valve insufficiency in terms of functional status. Even though the proportion of patients in the two groups who required pulmonary valve replacement was comparable, long-term follow-up is essential to assess how well utilising the transatrial-transpulmonary technique potentially protects the surgically corrected tetralogy of Fallot patients in our study from pulmonary valve replacement.

Limitations

There are several limitations to our study. First, our study contains the drawbacks of being a retrospective study and the patients' ages are slightly greater than in other studies, which might constitute a potential selection bias for definitive surgical repair, possibly impacting outcomes related to late presentation. Second, the follow-up period contains only the midterm (10 years) follow-up data, and it would be expected that in long-term follow-up, more patients will require reoperations for pulmonary valve replacement. Finally, our results of the definitive repair of tetralogy of Fallot utilising the transatrial-transpulmonary technique are a result of both specific surgical and cardiovascular ICU protocols at our centre for the management of these patients, which might not necessarily be able to be duplicated at other low-middle income cardiac surgical institutions.

Conclusions

The transatrial-transpulmonary repair for tetralogy of Fallot has excellent midterm outcomes in the setting of a cardiac centre in a low-middle-income country with patients requiring minimal pulmonary valve reoperations after definitive tetralogy of Fallot repair. Close long-term follow-up is critical for patients with an mini transannular patch who may require pulmonary valve replacement in the future.

Acknowledgements. The authors would like to show their deepest gratitude to Dr Casey Culberson for his kind advisors and valuable comments to the VNCH team.

Financial support. None.

Competing interests. None.

Ethics standards. 887/BVNTW-VNCSKTE.

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https://doi.org/10.1017/S1047951124000441 Published online by Cambridge University Press

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