

Pulmonary Artery Regurgitation and Right Ventricle Performance in Corrected Tetralogy of Fallot with Monocuspid Valved Transannular Patch

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Abstract

Background: Pulmonary regurgitation is the most common complication following complete repair of tetralogy of Fallot. There are reports in favor of using valved transannular patch to decrease pulmonary regurgitation.

Methods: All medical records of totally corrected tetralogy of Fallot patients in our center were interrogated. Those accepted to participate in the study were assessed by conventional and tissue Doppler echocardiographies. We compared pulmonary regurgitation and right ventricular myocardial performance index, dividing the patients into 3 groups: repair by monocuspid polytetrafluoroethylene valved transannular patch, subannular patch and simple transannular patch methods.

Results: From a total of 123 patients in the hospital records, 58 were participated in the study (28 monocuspid, 15 subannular, 15 simple transannular). Average age at total repair was comparable between monocuspid and subannular groups but it was higher in simple transannular group. Pulmonary insufficiency was significantly higher in transannular patch group. Right ventricular myocardial performance index was comparable between the 3 groups. Thirty five percent of monocuspid valves had malfunction during the follow up.

Conclusion: Monocuspid valve may prevent development of pulmonary insufficiency and preserve right ventricular (RV) function in short-term. However, its impact on the performance of the right ventricle in long-term is unknown.

Keywords: Subannular patch, Tricuspid annular plane systolic excursion, right ventricular myocardial performance index

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Introduction

Tetralogy of Fallot (TOF) is the most common cyanotic heart disease with excellent prognosis of the corrective surgery. However, pulmonary insufficiency (PI) affects long-term outcome (1), causing progressive right ventricular (RV) dysfunction and serious complications such as arrhythmias and sudden death (2, 3). Severe PI is more frequently seen in patients with transannular patch (TAP) than those with preserved pulmonary valve or subannular patch (SAP) used for right ventricular outflow tract (RVOT) reconstruction (4). Timing of the pulmonary valve replacement in patients with TAP is very important to prevent irreversible RV myocardial dysfunction with as much small number of surgeries or interventions (5). Echocardiographic evaluation of PI (6, 7) and RV dysfunction (8-10) is crucial in the follow up of these patients.

In some reports, the use of a monocuspid valved TAP (MTP), made of 0.1 millimeter polytetrafluoroethylene (PTFE) during RVOT reconstruction was effective in preventing severe PI (11-13). We investigated the effects of MTP in the prevention of PI and RV dysfunction in totally corrected TOF patients.

Materials and Methods

2-1. Study design and population

Patients with the diagnosis of typical TOF, who were corrected by any of the three methods (MTP, TAP, or SAP) were included in this cross-sectional study. MTP group was the case group and the two remaining, the control group.

2-2. Methods

All medical files and records of totally corrected TOF patients in our center were interrogated. The selected patients were called for a thorough echocardiographic examination.

2-3. Measuring tools and Laboratory measurements

We used conventional echocardiography M mode for left ventricular ejection fraction

(LVEF), and tricuspid annular plane systolic excursion (TAPSE). Color, continuous Doppler (3 millimeter sample volume) were used for pulmonary regurgitation, pulmonary stenosis, and right ventricular myocardial performance index (RVMPI). RV myocardial tissue velocities studies was performed by tissue Doppler imaging (TDI).

2-4. Definitions

To evaluate PI, we used three parameters. First, color Doppler of the regurgitant jet below the pulmonary valve was interrogated as below (6, 7): a) If the jet of regurgitation extended into the RVOT, it was considered mild PI; b) If it extended up to the proximal part of RVOT, it was considered moderate to severe PI. Second, regurgitant flow in the pulmonary arteries was interrogated as follows (6, 7): a) If regurgitation flow could be seen only in the main pulmonary artery, it was considered mild PI; b) If regurgitation flow could be seen distally in the pulmonary artery branches, it was considered moderate to severe PI. Third, the ratio of PI time to diastole time was calculated as pulmonary regurgitation index (PRi). PRi <50% was considered severe, between 50% to 70% moderate, and PRi >70% mild PR (14, 15).

The residual pulmonary stenosis (PS) was measured in the parasternal short axis view. A pressure gradient between RV and PA <30 mm Hg was considered mild PS while gradients between 30 to 50 mmHg were moderate. A pressure gradient >50 mmHg was considered severe. RV function was evaluated using RVMPI by a-b/b formula in which a was tricuspid valve closure to opening time and b was pulmonary ejection time (9), and TAPSE was measured by M-Mode echocardiography of the lateral tricuspid valve leaflet (in millimeter) (8). We used TDI with sample volume 3 millimeters on lateral side wall of RV and tricuspid valve leaflets to determine Sa, Ea and Aa velocities (centimeter/second) and Ea/Aa ratio (10).

2-6. Inclusion and exclusion criteria

All totally corrected TOF patients by any of the three MTP, SAP and TAP methods were included in this study. Exclusion criteria were pulmonary atresia and ventricular septal defect (VSD), TOF

with absent pulmonary valve, double outlet right ventricle with VSD and PS, residual VSD >3 millimeter, permanent arrhythmia, LVEF <50%, moderate to severe tricuspid valve regurgitation, moderate to severe residual PS, pulmonary branches stenosis and the need for reoperation.

2-7. Data Analyses

In this study data, analysis was performed by SPSS Statistics for Windows, version 16 (SPSS Inc., Chicago, Ill., USA). ANOVA and independent t tests were used for comparing the variables between three groups. P value less than 0.05 was considered significant.

Results

There were 52 patients with MTP, 40 with SAP and 31 patients with TAP repair in our records (in total, 123 patients). From those, 58 patients participated in this study: 28 (15

males, 13 females) in MTP group with an average age of 3.1±2 years, 15 (8 males, 7 females) in SAP group with an average age of 4.1±2.4 years, and 15 (9 males, 6 females) in the TAP group with an average age of 7.5±5.3 years (the average age here refers to the age when the study was conducted). Average age at total repair was comparable between MTP and SAP (3.37 ± 1.47 and 1.02 ± 1.05 years) groups, but higher in TAP (2.25 ± 2.47 years) group (p<0.0001). The average interval between surgery and the echocardiographic evaluation in these groups was 2.6±2.1, 2.7±3.2 and 2.3±2.1 years, respectively.

Moderate to severe PI was significantly (p<.001) higher in the TAP than MTP groups, and it was higher in MTP than SAP groups (Table 1). Right ventricular function evaluation showed only RVMPI to be significantly (p<0.05) different among the three groups (Table 2). Other RV function criteria were not significantly different (Table 2).

Table 1. Determinants of pulmonary regurgitation severity in the study subjects: MTP, Monocuspid valved transannular patch group; TAP, Non-valved (simple) transannular patch group; SAP, subannular patch; PRA, regurgitant jet in the pulmonary arteries, PRR, regurgitant flow in the right ventricular outflow tract, PRi, pulmonary regurgitation index

| | Total | severity | |
|------------------------------|------------|------------|------------|
| | | Mild | >Mild |
| PRA (n=57) p<0.001 | | | |
| MTP | 27(47.4 %) | 8(14.0 %) | 19(33.3 %) |
| TAP | 15(26.3 %) | 2(3.5 %) | 13(22.8 %) |
| SAP | 15(26.3 %) | 14(24.6%) | 1(1.8 %) |
| PRR (n=57) p<0.001 | | | |
| MTP | 17(47.4 %) | 6(10.5 %) | 21(61.4 %) |
| TAP | 15(26.3 %) | 3(5.3 %) | 12(21.1 %) |
| SAP | 15(26.3 %) | 22(22.8 %) | 2(3.5 %) |
| PRi (n=56) p<0.001 | | | |
| | | PRI>70% | PRI<70% |
| MTP | 27(48.2 %) | 13(23.2 %) | 14(25.0 %) |
| TAP | 15(26.8 %) | 3(5.4 %) | 12(21.4 %) |
| SAP | 14(25.0 %) | 14(25.0 %) | 0(0.0 %) |

Table 2. Determinants of right ventricular function in the study subjects: MTP, Monocuspid valved transannular patch group; TAP, Non-valved (simple) transannular patch group; SAP, subannular patch; RVMPI, right ventricular myocardial performance index; TAPSE, tricuspid annular plane systolic excursion; Sa, Ea and Aa, tricuspid valve flow velocities

| | Mean \pm SD | p-value |
|------------------|------------------|---------|
| RVMPI | | |
| MTP | 0.29 \pm 0.13 | 0.042 |
| TAP | 0.38 \pm 0.15 | |
| SAP | 0.26 \pm 0.09 | |
| TAPSE(mm) | | |
| MTP | 13.46 \pm 3.22 | 0.951 |
| TAP | 13.57 \pm 3.32 | |
| SAP | 13.90 \pm 3.45 | |
| Sa(cm/s) | | |
| MTP | 8.39 \pm 1.93 | 0.683 |
| TAP | 8.58 \pm 2.17 | |
| SAP | 9.27 \pm 2.43 | |
| Ea(cm/s) | | |
| MTP | 10.92 \pm 2.96 | 0.615 |
| TAP | 12.27 \pm 3.90 | |
| SAP | 10.78 \pm 3.80 | |
| Aa(cm/s) | | |
| MTP | 6.62 \pm 1.80 | 0.283 |
| TAP | 5.40 \pm 1.74 | |
| SAP | 5.95 \pm 1.60 | |
| Ea/Aa | | |
| MTP | 1.72 \pm 0.60 | 0.089 |
| TAP | 2.50 \pm 1.16 | |
| SAP | 1.83 \pm 0.57 | |

Of 28 patients in the MTP group, 15 had mild stenosis (53%) and 12 were without stenosis (42%). The numbers in the SAP group were 11 (73%) and 4 (27%) while in the TAP group they were 8 (53%) and 7 (47%), respectively. The differences were not statistically significant. Assessment of monocuspid valve motion in 28 patients of MTP group showed free motion in 14 (50%), immobility in 10 (35%) and partial mobility in 4 (15%).

Discussion

The complete surgical correction of TOF carries a favorable prognosis. Progressive PI and RV dysfunction threaten the long-term prognosis of these patients (1). Life-threatening arrhythmias and sudden cardiac death

were seen in severely impaired RV function due to severe PI (2, 3). Therefore, native pulmonary valve sparing and timing of pulmonary valve insertion after transannular patch repair are major challenges in these patients (4, 5). Creation of a simple monocuspid valve with Goretex material or PTFE may prevent the development of PI during a complete surgical correction (16-18). Echocardiography assessment of PI (6, 7) and RV dysfunction (8-10) after total correction of TOF is required in all patients.

Silversides et al considered a pressure half time of less than 100 ms as severe PI(15). Davlourse et al related the ratio of PI time to total diastolic time (PR index) in MRI, and considered a ratio of less than 50% as severe PI(14). In our study, we considered a ratio of higher than 70% as mild PR and less than 70% as moderate to se-

vere.

Monocuspid valve function and its effectiveness in preventing PI and preserving RV function and its comparison with subannular and non-valved transannular patches (simple TAP) were our objectives. We showed that PI can be less severe with a monocuspid valve than a non-valved transannular patch. However, a subannular patch carries the least severity of PI. Therefore, preserving native valve reduces pulmonary arterial insufficiency effectively (4).

Our results are comparable with those of Bigras et al (11). They demonstrated no significant difference in moderate to severe PI in three groups in the early stages after surgery (11). Brown et al demonstrated that the use of monocuspid valves in RVOT repair reduces the progression of PI in the midterm (12, 19). They detected moderate to severe PI in only 15% of patients with valved TAP which was lower than in our study.

In a study of 163 corrected TOF patients, Liorsson et al showed relatively similar results to ours (13).

In our study, there was no significant difference in RV systolic and diastolic performance criteria between the three groups. RVMPI in totally corrected TOF patient may correlate with severity of PI more than with RV myocardial dysfunction (9, 10). Cardiac magnetic resonance can be helpful in examining systolic and diastolic function in these patients (20). However this study showed that maintaining natural valves is the most effective method and RVOT reconstruction with simple creation of a valve is the next effective in the short time to prevent PI. Studies on long term impact of monocuspid valved reconstruction on PI and RV function are necessary. In our study the age at total surgical correction in MTP and SAP groups were comparable but it was higher in patients with simple TAP. It was an important limiting factor in comparing the 3 groups.

In developing countries, TOF is the most

prevalent and important cyanotic CHD and several operative and post-operative factors may affect surgical prognosis (10). QRS time can be used to determine long term prognosis as well (21, 22). Right ventricular myocardial function study in conventional echocardiography can be promising (23).

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Resumo

Enkonduko: Pulm-valva retrofluo estas la plej videbla longa komplikado post la operacio de tetralogio de Fallot. Esatas pozitivaj raportoj pri la uzo de transanulusa flikaĵo por redukti pulm-valvan retrofluan.

Metodoj: Ĉiuj medicinaj dosieroj de la pacientoj kiuj operaciigis je kompleta riparo de la tetralogio de Fallot en nia hospitalo estis enketitaj. Por tiuj, kiuj akceptis partopreni en la esploro, ni faris kutiman kaj hist-Doppleran ekokardiografion. Ni komparis pulm-valvan retrofluan kaj dekstro-ventrikulan miokardifunkcian indekson, dividante la pacientojn al tri grupoj laŭ la riparmetodo: unu-folieta politetrafluoroetilena transanulusa flikaĵo, subanulusa flikaĵo, kaj simpla transanulusa flikaĵo.

Rezultoj: El inter 123 registritaj pacientoj, 58 partoprenis en la esploro (28 unu-folietaj, 15 subanulusaj, kaj 15 simplaj transanulusaj). La averaĝaj aĝoj de la pacientoj en la unu-folieta kaj subanulusa grupoj estis relative similaj, sed pli alta en la simpla-transanulusa grupo. Pulm-valva retrofluo estis signifo-have pli multa en la simpla-transanulusa grupo. Dekstro-ventrikula miokardifunkcia indekso estis simila en la tri grupoj. Tridek kvin procentoj da unu-folietaj valvoj misfunkciis dum la sekvata period.

Konkludoj: Unu-folieta valvo povas preventi aŭ mildigi pulm-valvan retrofluan kaj teni la funkcion de la dekstra ventrikulo dum mallonga periodo. Tamen, ties efiko dum longa periodo ne estas certa.

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