Original Article

Transatrial/Transpulmonary Approach versus Transventricular Approach in Classical Tetralogy of Fallot Repair

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Abstract

Background: Right ventricular dysfunction is an important cause of morbidity and mortality following total correction of tetralogy of Fallot (TOF). Transatrial/transpulmonary approach avoids ventriculotomy (as opposed to the transventricular approach) which gives maximum protection of the right ventricle structure and function. **Objectives:** The main objective is to review the results of transatrial/transpulmonary approach and compare it with that of the transventricular approach. **Patients and Methods:** Forty patients underwent repair of classical TOF were retrospectively studied from January 1, 2015 to January 1, 2018 at Ibn Al-Nafees Teaching Hospital for cardiothoracic surgery in Baghdad, Iraq. We divided the patients into two groups: group A (transventricular approach group) – 22 patients, and Group B (transatrial/transpulmonary approach group) – 18 patients. In this study, we did comparison between these two groups. **Results:** There were eight operative deaths; the overall mortality was 20%, six patients in Group A (27.27%) versus two patients in Group B (11.11%). Severe right ventricular systolic dysfunction after repair was found in 14 patients (35%), 11 patients in Group A (50%) versus 3 patients in Group B (16.66%). Tachyarrhythmias were seen in 18 patients after repair (45%); 13 patients in Group A (59.09%) versus 5 patients in Group B (27.7%). **Conclusion:** Transatrial/transpulmonary approach procedure in the TOF surgery is more safe and associated with lower morbidity and mortality than the transventricular approach.

Keywords: Tetralogy of Fallot, transatrial repair, transventricular approach, ventriculotomy

Introduction

Virtuous repair of tetralogy of Fallot (TOF) can be expected with low risk, which is estimated to be under 5% in many centers, in spite of a reasonable pattern for repair early in life.[1] Regardless of the incredible early outcomes of traditional transventricular approach, late right ventricular dilatation and dysfunction, tricuspid and pulmonary valve incompetence, and ventricular arrhythmias have been accounted. These troublesome outcomes are acknowledged to be related to the long infundibulotomy.[2] The focal element of transatrial/transpulmonary repair is the strict evasion of a transmural infundibulotomy.[3] Utilizing this approach, the surgeon can successfully carry out a satisfactory infundibular resection up to the level of the pulmonary valve annulus.[3] The transatrial/transpulmonary approach is relevant to every single anatomic variety, incorporating those patients in whom an anomalous coronary artery is available.[4]

There are a few vital restrictions in applying a transatrial/transpulmonary approach, specifically in those infant patients with pulmonary atresia.[5] The next critical impediment of this approach is that it is to a great degree hard to educate[6] and has the potential for traction damage on the tricuspid valve, and conduction organization, thus, it is linked with amplified hazards of tricuspid incompetence (TI) and complete heart block (CHB).[7]

At long last, there is no doubt that the transatrial/transpulmonary approach is in fact technically more challenging than the transventricular approach. Operative times have a tendency to be longer, in addition to myocardial ischemic intervals. This does not seem to have converted into any obvious hindrance.[8] Transatrial/transpulmonary approach patients had a higher rate of reoperation for remaining right ventricular outflow tract (RVOT) obstruction than the transventricular approach,[9] this must be weighed against the more serious requirement for

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pulmonary valve replacement (with inescapable consequent numerous reoperations), late right ventricle (RV) dilatation and dysfunction, arrhythmias and the need for defibrillator, and conceivable late sudden death as late incapacitation after transventricular repair.[2,10]

The aim of this study is to review the results of transatrial/transpulmonary approach, compare it with that of transventricular approach, and evaluate our experience in classical TOF repair.

Patients and Methods

Forty patients, aged from 3.5 to 25 years old, underwent elective repair of classical TOF and were retrospectively studied from January 1, 2015 to January 1, 2018 at Ibn Al-Nafees Teaching Hospital for Cardiothoracic Surgery in Baghdad, Iraq. Twenty-four patients were female and 16 patients were male. A transventricular approach was used in 22 patients; a transatrial/transpulmonary approach was used in 18 patients. Transannular patch was necessary in seven patients. Most patients were referred from the pediatric cardiology unit to the cardiac surgery unit; all cases were assessed by pediatric cardiologist preoperatively and postoperatively.

The diagnostic modalities which were used for all patients were electrocardiography, chest X-ray, and transthoracic echocardiography. Diagnostic cardiac catheterization was employed in 15 patients only. All patients were cyanotic TOF; none of those cases had a previous palliative shunt or reoperation. Most patients had associated lesion, 18 patients had patent foramen ovale, 6 patients had a persistent left superior vena cava, 3 patients had additional muscular ventricular septal defects (VSDs), and 3 patients had anomalous coronary arteries (left anterior descending coronary artery from the right coronary artery). All patients underwent classical median sternotomy, total cardiopulmonary bypass, antegrade crystalloid cardioplegia, and left ventricular venting. Intraoperative measurement of the pressure ratio between the RV and left ventricle or the RV-pulmonary artery gradient after the repair was not employed. All cases assessed postoperative by transthoracic echocardiography in early postoperative period and before discharge. We divided the patients into two groups according to the procedure used in repair, in Group A, a transventricular approach was used (22 patients), and in Group B, a transatrial/transpulmonaryapproach was used (18 patients). We reviewed the advantage and the disadvantage of those two approaches, compared the results of two procedures and their early complications, and evaluate our experience in TOF repair. We used the following parameters to compare between the two groups: Age, aortic cross-clamp, cardiopulmonary bypass time, intensive care unit stay, postoperative tachyarrhythmias, prolonged ventilation, postoperative heart block, postoperative wound infection, residual VSD, postoperative right ventricular function, incidence of pulmonary incompetence, postoperative respiratory tract infections, residual RVOT obstruction, incidence of tricuspid incompetence, postoperative pericardial effusion, the need for inotropic support, and mortality.

Statistical analysis

The SPSS program version 22 (IBM Corp., Armonk, N.Y., USA) was utilized for factual investigation. The outcomes were communicated by the mean and standard deviation for persistent factors or with recurrence and rate for absolute factors. Pearson Chi-square test was utilized for correlation and estimating affiliation. $P < 0.05$ were thought to be measurably huge.

Results

Fifteen patients were aged between 6 and 10 years (37.5%), which was the common age in both groups, 6 patients in Group A (27.27%) and 9 patients in Group B (50%). Female-to-male ratio was 1.5:1 [Table 1].

Table 2 summarizes the mean value of comparative variables between Groups A and B.

There were 8 operative deaths; overall mortality was 20%, six patients in Group A (27.27%) versus two patients in Group B (11.11%). Severe right ventricular systolic dysfunction after repair was found in 14 patients (35%), 11 patients in Group A (50%) versus 3 patients in Group B (16.66%); 2 patients

Table 1: Age and gender distribution of patients

Variable	Group A (%)	Group B (%)	Total (%)	*P*
Age (years)				
3.5-5	11 (50)	0	11 (27.5)	0.00044
6-10	6 (27.27)	9 (50)	15 (37.5)	0.13888
11-15	4 (18.19)	2 (11.11)	6 (15)	0.53526
16-20	1 (4.54)	5 (27.78)	6 (15)	0.04036
21-25	0	2 (11.11)	2 (5)	0.1096
Total	22 (100)	18 (100)	40 (100)	
Gender				
Female	13 (59.09)	11 (61.11)	24 (60)	0.89656
Male	9 (40.91)	7 (38.89)	16 (40)	0.89656
Total	22 (100)	18 (100)	40 (100)	

Table 2: Mean values of comparative variables between Group A and Group B

Variable	Group A	Group B	*P*
Body weight (kg)	9.35	10.66	0.890
Body surface area (m^2)	0.81	0.97	0.667
Aortic cross-clamp time (min)	79	93	0.479
Cardiopulmonary bypass time (min)	164	117	0.547
Intubation time (h)	18.8	6.86	0.0219
Intensive care unit stay (day)	5.8	3	0.357
Need for high inotropic support time (day)	3.05	0.75	0.0245
Postoperative tricuspid annular plane systolic excursion value (cm)	0.62	1.74	0.0397

of those 14 patients died immediately postoperatively. Postoperative acute renal failure (which is largely related to severe RV systolic dysfunction) was observed in 15 patients (37.5%), 12 patients in Group A (54.54%) versus 3 patients in Group B (27.77%); 3 patients of those 15 patients were died and the other 12 patients were improved. Tachyarrhythmias were seen in 18 patients after repair (45%); 13 patients in Group A (59.09%) versus 5 patients in Group B (27.77%). Postoperative CHB was observed in 8 patients (20%), 6 patients in Group A (27.27%) versus 2 patients in Group B (11.11%); 3 patients of those 8 patients were died, other 3 patients needed a permanent pacemaker, and 2 patients were improved. Residual RVOT obstruction was prominent in 11 patients (27.5%), 7 patients in Group A (31.63%) versus 4 patients in Group B (22.23%). Residual VSD was seen in 4 patients (10%), 3 patients in Group A (13. 63%) versus 1 patient in Group B (5.55%). Pulmonary incompetence was seen in 9 patients postoperatively (22.5%), 8 patients in Group A (36.35%) versus 1 patient in Group B (5.55%). Tricuspid incompetence postrepair was found in 6 patients (15%); 2 patients in Group A (9.09%) versus 4 patients in Group B (22, 22%). Postoperative bleeding and pericardial effusion were noticed in 8 patients (20%) and 4 patients (10%), respectively. Respiratory tract infections and wound infections were observed in 18 patients (45%) and 26 patients (65%) correspondingly in the two groups [Table 3].

Transannular patches were applied in 7 patients (17.5%), 6 patients in Group A (27.27%) versus 1 patient in Group B (5.55%). For repair of VSDs, Dacron patches were used in 21 patients (52.5%) and pericardial patches were used in 19 patients (47.5%), In Group A, pericardial patches were used in 8 patients (36.36%) and Dacron patches were used in 14 (63.63%) patients, while in Group B, pericardial patches were applied to 11 patients (61.11%) versus Dacron patches were used in 7 patients (38.89%). All transannular patches were pericardial patches (100%). Three patients (7.5%) had anomalous coronary arteries; all were detected in Group B (16.66%) versus no any patient in Group A (0%) [Table 4].

Discussion

Various studies have exhibited the benefits of early TOF repair, including the advancement of ordinary growth and organ development, the alleviation of cyanosis, and a diminished events of dysrhythmias, which was shown among the patients who experienced TOF repair before a half year of age.[11,12] In the present study, the mean age of the patients was 10.08 years, ranging from 3.5 to 25 years, which was very high compared with other studies abroad where the mean age was in days as many centers do repair TOF in the neonatal period or early childhood, and this reflects that our experience still far away from that worldwide. Female-to-male ratio was 1.5:1 which is different from that seen in other studies where the ratio was equal.[13] This study showed an overall mortality of 20% which was very high compared to other studies abroad which was only 5% or even less.[1,14] We need more experience in TOF repair and postoperative care. The operative death was 6 patients in Group A (from 22 patients repaired by transventricular approach) (27.27%), while operative death was only 2 patients in Group B (from 18 patients repaired by transatrial/transpulmonary approach) (11.11%), reflected safety of this procedure compared to transventricular approach which may be due to good postoperative right ventricular systolic function due to avoidance of ventriculotomy. Severe right ventricular systolic dysfunction evaluated by postoperative value of tricuspid annular plane systolic excursion value (TAPSE) estimated to be >1 cm, was 50% in Group A versus only 16.66% in Group B which showed the main advantage of transatrial/transpulmonary approach by avoiding ventriculotomy (as opposed to the transventricular approach) and better preservation of RV structure and function;[3,15] the mean postoperative TAPSE was higher in Group B 1.74 cm versus 0.62 cm in Group A reflected better RV systolic function. Mean aortic cross-clamp time was higher in Group B without adverse effects on the outcome

Table 3: Comparison of morbidity and mortality between the two groups after tetralogy of FOallot repair

Variable	Group A (22 patients)	Group B (18 patients)	Total (%)	*P*
Tricuspid incompetence	2 (9.09)	4 (22.22)	6 (15)	0.24604
Tachyarrhythmia	13 (59.09)	5 (27.77)	18 (45)	0.0477
Bleeding	5 (22.72)	3 (16.66)	8 (20)	0.63122
Complete heart block	6 (27.27)	2 (11.11)	8 (20)	0.20408
Pulmonary incompetence	8 (36.35)	1 (5.55)	9 (22.5)	0.02034
Residual VSD	3 (13.63)	1 (5.55)	4 (10)	0.39532
Respiratory tract infection	11 (50)	7 (38.88)	18 (45)	0.48392
Wound infection	16 (72.72)	10 (55.55)	26 (65)	0.25848
Pericardial effusion	3 (13.63)	1 (5.55)	4 (10)	0.39532
Residual RVOT	7 (31.81)	4 (22.23)	11 (27.5)	0.4965
Severe right ventricle systolic dysfunction	11 (50)	3 (16.66)	14 (35)	0.0278
Acute renal failure	12 (54.54)	3 (27.77)	15 (37.5)	0.0139
Mortality	6 (27.27)	2 (11.11)	8 (20)	0.20408

VSD: Ventricular septal defect, RVOT: Right ventricular outflow tract

Table 4: Associated anomalies, type of patches used for repair of ventricular septal defects and transannular patches usage in two groups

Associated anomaly	Group A	Group B	Total (%)
Patent foramen ovale	12 (54.54)	6 (33.33)	18 (45)
Persistent left superior vena cava	4 (18.18)	2 (11.11)	6 (27.27)
Muscular ventricular septal defects	2 (9.09)	1 (5.55)	3 (7.5)
Anomalous coronary arteries	0	3 (16.66)	3 (7.5)
Transannular patch usage	6 (27.27)	1 (5.55)	7 (17.5)
Dacron patch	14 (63.63)	7 (38.89)	21 (52.5)
Pericardial patch	8 (36.36)	11 (61.11)	19 (47.5)

due to the fact that transatrial/transpulmonary approach is more technique dependent,[8] mean cardiopulmonary bypass time was much more in Group A which carry more adverse effects on the heart. In our series, 7 patients out of 8, their age was between 16 and 25 years, a transatrial/transpulmonary approach was applied, while all patients whom their age was between 3.5 and 5 years, a transventricular approach was applied; which reflect that the transatrial/transpulmonary approach is more technique dependent and was applied in older age groups where good space of repair was present. In our study, tricuspid incompetence incidence was higher in Group B (22.22%) compared to Group A (9.09%), may be due to traction applied on tricuspid valve in transatrial/transpulmonary approach or trauma to its apparatus during resection, this finding is correspondent with the findings worldwide.[7,16] CHB had higher incidence in Group A (27.27%) than in Group B (11.11%), which is opposite to the findings in other international studies where CHB was observed higher in transatrial/transpulmonary approach[7,16] which is due to strong traction on AV node related to the small size of the patients as the repair was done in the neonatal period, while in our study, repair was done in older age groups where strong traction on AV node was not needed due to large space available.

Pulmonary incompetence was found in 36.35% of patients in Group A, which is higher than that seen in Group B (5.55%), this is so vital for the late outcome as late RV dilatation, late RV dysfunction, late arrhythmias, and sudden death were found to be more in patients with postrepair pulmonary incompetence, in addition to the need for reoperation for pulmonary valve replacement.[17] Postoperative tachyarrhythmias were observed in a higher incidence in Group A (59.09%) versus only (27.77%) in Group B, reflected that ventriculotomy was arrhythmogenic.[18] Residual VSD and residual RVOT obstruction had lower incidence in Group B than Group A, which reflect feasibility of transatrial/transpulmonary approach to repair VSD, and the overall incidence of residual VSD in our patients was due to low experience in TOF repair. There was low incidence of residual RVOT obstruction in transatrial/transpulmonary approach compared to that in transventricular approach in our study, which is opposite to observations in other studies abroad, and this discrepancy may be due to feasibility to resect subpulmonic stenosis where large space available in older patients.

Overall incidence of postoperative acute renal failure in our study was high (37.5%) which is largely related to the severe RV systolic dysfunction postoperatively, 15 patients of 40 patients had postoperative acute renal failure, 3 patients of them died versus 12 patients were recovered, and the incidence of postoperative acute renal failure was higher in Group A (54.54%) versus (27.77%) in Group B which reflect poor cardiac output in Group A which is may be related to ventriculotomy. Incidence of respiratory tract infections, wound infections, pericardial effusion, and bleeding showed no significant difference among the two groups. All three patients whom had anomalous coronary arteries were repaired by transatrial/transpulmonary approach (100%) which provided excellent feasibility without injury to those anomalous coronary arteries and this is also a trend worldwide.[4]

Transannular patches usage were higher in Group A (27.27%) versus (5.55%) in Group B reflected preference of transventricular approach in the presence of hypoplastic pulmonary valve, which is also the trend abroad.[19]

Mean of intubation time, need for higher inotropic support time, and intensive care unit stay were higher in Group A versus Group B which reflect high morbidity in Group A.

Study limitation

Absence of long term follow up for occurrence of complications (Such as late RV dilatation, late RV dysfunction, late arrhythmia with sudden death, whether Defibrillator or reoperation was needed). This is because of the loss of contact with the patients.

Conclusion

Total repair of classical TOF by transatrial/transpulmonary approach is a standard procedure, and this approach is related with amazingly low morbidity and mortality versus transventricular approach. Transatrial/transpulmonary repair is an excellent approach for TOF associated with anomalous coronary arteries. Our experience in TOF repair is still far away from that worldwide. We need more experience in transatrial/transpulmonary approach.

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Conflicts of interest

There are no conflicts of interest.

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