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Cardiothoracic Surgery

# Reoperations after the primary repair of tetralogy of Fallot; a single-center experience

**Ahmed Mahmoud Eldesouky[1] MSc; Elhusseiny Elhusseiny Gamil[1] MD; Eldesouky Mohamed Sharaa[1] MD; Mohamed Elsayed Mosa[1] MD; Haytham Mohammed Abdelmoaty[1] MD**

** Corresponding Author:*
Ahmed Mahmoud Eldesouky
agtantawy@yahoo.com

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[1]*Cardiothoracic Surgery Department, Al-Azhar University, Faculty of Medicine, Al-Azhar University, Cairo, Egypt.*

**ABSTRACT**

**Background:** Reoperations after tetralogy of Fallot repair is common. This study aimed to report our indications, surgical procedures, and the clinical outcomes of patients undergoing reoperation after surgical correction of TOF.
**Patient and Methods:** We included 40 patients who underwent reoperations after total TOF repair between 2015 and 2019. We included patients who had symptomatic right ventricular failure, patients with residual ventricular septal defect (VSD), right ventricular outflow tract obstruction (RVOTO), and tricuspid or pulmonary valve regurgitation.
**Results:** The median age was 5.5(3.5–12.5) years, and 28(70%) were males. The median age at the time of primary repair was 2 (1-6) years. The end-systolic right ventricular (RV) volume estimated by MRI was 110.33±4.93 cc, and the end-diastolic volume was 208 ±10.08 cc. Twenty-two patients had VSD closure (55%), a transannular patch in 6 patients (15%), and RVOT resection in 14 patients(35%). Pulmonary valve replacement was performed in 6 patients(15%) and tricuspid valve repair in 4 patients (10%). The duration of postoperative mechanical ventilation was 11.5 (9-16.5) hours, and two patients had operative mortality (5%). Two patients (5%) had residual RVOT pressure gradient, and four patients had tiny residual VSD(10%). After six months of follow-up, four patients had moderate pulmonary regurgitation (PR), and four patients had residual VSD (10%). After one year follow-up, two patients had moderate PR(5%).
**Conclusion:** A residual ventricular septal defect is a common indication for reoperation after the primary repair of tetralogy of Fallot. The results of reoperations are good with the accepted incidence of postoperative morbidity and mortality.
**Keywords:** *Tetralogy of Fallot; Reoperations; Residual ventricular septal defects.*

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## INTRODUCTION

Tetralogy of Fallot (TOF) is a common congenital problem with an incidence of 3.5% of all congenital heart disease.[1]

Total primary repair is the recommended treatment; however, staged correction is still performed in some centers, especially in symptomatic infants under three months of age.[2]

The surgical results of total repair of TOF have improved because of the advancement of the operative techniques and perioperative care, Despite the improved survival, several complications were reported over the long-term follow-up.[3]

Arrhythmia is common after TOF repair because of the right ventricular incision.[4]

Pulmonary regurgitation is a common problem after the repair, which leads to progressive right ventricular dilatation and functional tricuspid regurgitation.[5]

Pulmonary valve replacement is frequently performed in adults following TOF repair.[6] Surgical techniques have evolved further to perform a trans-atrial repair to avoid ventricular incision; additionally, it is recommended to avoid pulmonary trans-annular patch and perform concomitant tricuspid repair during the primary TOF correction.[2]

Reoperations are after TOF repair are frequent, and few studies are describing this problem in our region. Our objectives were to report our indications, surgical procedures, and the clinical outcomes of patients

undergoing reoperation after surgical correction of TOF.

## PATIENT AND METHODS

Design and patients:
This study included 40 patients who underwent reoperations after total TOF repair between September 2015 and December 2019 in a single institution. We included patients who had symptomatic right ventricular failure, patients with residual ventricular septal defect (VSD), right ventricular outflow tract obstruction (RVOTO), and tricuspid or pulmonary valve regurgitation. We excluded patients with insignificant residual hemodynamic problems.

Ethical considerations:
The Local Ethical Committee approved the study, and consent to participate in the research was obtained from the patients prior to their enrollment in the study.

Data collection and technique:
We collected the preoperative patients' data, including age, gender, weight, routine laboratory data, and echocardiography. Echocardiographic data were the size and position of the residual VSD, degree, and level of residual RVOTO, diameters of the main pulmonary artery, and stenosis of the pulmonary artery or its branches, degree pulmonary regurgitation and tricuspid valve regurgitation, cardiac dimensions, and ejection fraction. We performed a cardiac catheterization and CT angiogram in selected patients when indicated. Magnetic resonance imaging (MRI) was performed in patients who needed a pulmonary valve replacement.
Intraoperatively, we examined the cardiac anatomy, including the main pulmonary artery and its branches, pulmonary annulus, RVOT, the ventricles, and the coronary arteries. We assessed the location and extension of the residual VSD, tricuspid valve apparatus, and RVOT.
The surgical procedures differed according to the indications for reoperation. We performed the intervention under moderate hypothermia and cardiac arrest. We accessed the lesions through the right atrium incision, and any infundibular hypertrophy was resected. The tricuspid valve was retracted to expose VSD, and we closed the defect with a prosthetic patch (Gore-Tex patch, W. L. Gore & Associates, Flagstaff, Arizona, USA). In some patients, the septal leaflet of the tricuspid valve was detached for proper VSD exposure. We then evaluated the pulmonary valve and its annulus. We defined pulmonary stenosis as one standard deviation less than the predicted by Rowlatt's standard charts intraoperatively. Patients with pulmonary stenosis had transannular repair with a pericardial patch. We extended the patch distally to manage any concomitant pulmonary artery stenosis.
Sub pulmonary RVOTO was managed with infundibular resection. We measured the diameter of the RVOT and the pulmonary valve with Hegar dilators. Further stenosis was managed with pulmonary arteriotomy and valvotomy whenever appropriate. We evaluated the tricuspid valve function and performed valvuloplasty in patients with moderate or higher tricuspid regurgitation or with a dilated annulus. In patients who needed pulmonary valve replacement, a mechanical valve was used.
Patients were transferred to the intensive care unit postoperatively, and we reported the duration of mechanical ventilation, the need for inotropic support, and any postoperative complications. Patients were followed clinically and with echocardiography at six months and one year postoperatively.

Statistical analysis:
Quantitative data were presented as mean and standard deviation if normally distributed and median and interquartile range if non-normally distributed. Qualitative data are presented as number and percent. Descriptive analysis was performed using SPSS version 21 (IBM Corp- Chicago- IL- USA).

## Results

Baseline data
The study included 40 patients; 28 of them (70%) were males, and their ages ranged from 2 to 35 years. The median age at the time of primary repair was two years Table (1).

| Baseline data | n= 40 |
|---|---|
| **Age (years)** | 5.5 (3.5 – 12.5) |
| **Male** | 28 (70%) |
| **Weight (Kg)** | 15 (13.75 – 27.5) |
| **Favism** | 2 (5%) |
| **Age at the primary repair (years)** | 2 (1 – 6) |
| **NYHA class** | |
| **II** | 34 (85%) |
| **III** | 6 (15%) |
| **Hemoglobin (mg/dL)** | 11.17 ± 0.89 |
| **INR** | 1.06 ± 0.08 |
| **Platelets/ mm3** | 242.7 ± 60.53 |
| **WBCs** | 7.94 ± 2.74 |
| **ALT (Unit/L)** | 26.3 ± 11.99 |
| **AST (Unit/L)** | 29 (24 – 30) |
| **Creatinine (mg/dl)** | 0.64 ± 0.19 |

**Table 1:** Baseline data. Continuous data are presented as mean± SD or median and interquartile range and qualitative data as number and percent. ALT: alanine aminotransferase, AST: aspartate aminotransferase, INR: international normalization ratio; NYHA: New York Heart Association

Preoperative cardiac evaluation
Preoperative echocardiographic data showed that 22 patients had residual VSD (55%), and six patients (15%) had severe pulmonary regurgitation. Preoperative MRI was done in patients who required pulmonary valve replacement. End-systolic right ventricular (RV) volume estimated by MRI was

110.33 ± 4.93 cc, end-diastolic volume was 208 ± 10.08 cc, and stroke volume was 102 ± 2.37 ml/beat.

| Preoperative Echo data | n= 40 |
|---|---|
| **Residual VSD** | 22 (55%) |
| **Pulmonary stenosis** | 2 (5%) |
| **RVOTO** | 14 (35%) |
| **Severe pulmonary regurgitation** | 6 (15%) |
| **Severe tricuspid regurgitation** | 4 (10%) |
| **Mean pulmonary artery diameter (mm)** | 13.8 ± 5.29 |
| **Right pulmonary artery diameter (mm)** | 11.4 ± 2.89 |
| **Left pulmonary artery diameter** | 10.85 ± 4.38 |
| **Pulmonary annulus (mm)** | 10.7 ± 5.38 |
| **RVOT diameter (mm)** | 10.5 ± 5.99 |
| **Right ventricular ejection fraction (%)** | 46.5± 5.9 |
| **Left ventricular ejection fraction (%)** | 59.6± 6.0 |

**Table 2:** Preoperative echocardiographic data. Continuous data are presented as mean± SD or median and interquartile range and qualitative data as number and percent. RVOTO: right ventricular outflow tract obstruction, VSD: ventricular septal defect.

Operative data:
Twenty-two patients had VSD closure (55%). We performed a transannular patch in 6 patients (15%) and RVOT resection in 14 patients (35%). Pulmonary valve replacement was performed in 6 patients (15%) and tricuspid valve repair in 4 patients (10%). Mean cardiopulmonary bypass time was 58.55 ± 20.19 minutes, and cross-clamp time was 38 ± 13.24 minutes.

Postoperative outcomes:
The immediate postoperative outcomes are presented in table 3. Two patients had operative mortality (5%). Two patients (5%) had residual RVOT pressure gradient, and four patients had tiny residual VSD (10%). After six months of follow-up, four patients had moderate PR, and four patients had residual VSD (10%). After one year follow-up, two patients had moderate PR (5%).

| Postoperative outcomes | n= 40 |
|---|---|
| **Chest tube drainage (ml)** | 142.5 ± 106.55 |
| **Duration of mechanical ventilation (hours)** | 11.5 (9- 16.5) |
| **Postoperative arrythmia** | 6 (15.0%) |
| **Residual RVOT pressure gradient** | 2 (5%) |
| **Residual tiny VSD** | 4 (10%) |
| **Moderate pulmonary regurgitation** | 6 (15%) |
| **Moderate tricuspid regurgitation** | 2 (5%) |

**Table 3:** postoperative outcomes. Continuous data are presented as mean± SD or median and interquartile range and qualitative data as number and percent. RVOT: right ventricular outflow tract obstruction, VSD: ventricular septal defect.

## Discussion

Tetralogy of Fallot is the most common cyanotic heart disease. Reoperations after total repair of TOF is common mostly because of pulmonary regurgitation and progressive right ventricular dilatation.[7]
Other indications of surgical interventions include residual VSD or RVOTO. Studies on reoperations after TOF are few in our country, and we pursued this to report our experience with reoperation after TOF repair.
In this study, we included 40 patients who had reoperations after TOF repair. Their ages ranged between 2 and 35 years. Reoperations occurred mainly because of residual VSD (55%), RVOT obstruction (35%), pulmonary valve insufficiency (15%), and TR (10%). Male patients presented 70% of our population. In this study, two cases had operative mortality. During a 6-month follow-up, no patient showed signs of right ventricular failure.
In another study, the most common indications of reoperations after TOF were pulmonary valve insufficiency (51.4%), RVOT dilatation (45.9%), and residual VSD (43.2%).[8]
Several other studies reported the RVOTO as the most common cause of reoperations after TOF repair.[9,10]
In a survey among Japanese centers, the indications of reoperations varied in different centers, and the most common causes were pulmonary stenosis (32%) and regurgitation (29%).[11]
In this study, six patients had pulmonary valve replacement because of severe pulmonary regurgitation**.** The time interval between the initial repair and pulmonary valve replacement was 1 to 12 years. Tsang and colleagues reported pulmonary valve replacement in 16/38 patients, and the time from primary repair was 19 years. The indications of interventions were severe pulmonary regurgitation (n= 3), and asymptomatic progressive right ventricular dilatation (n=13).[12]

Our patients improved gradually from NYHA class III to class I postoperatively, which is a similar finding to other studies.[13,14]

PR following TOF repair was related to the use of a transannular patch during RVOT reconstruction and infundibular resection involving the pulmonary annulus. PR was reported in 80% of the patients following TOF repair.[3]

Four patients in our series had reoperation for tricuspid valve problems. The age at the time of reoperation ranged from 14 to 17 years. We did not report operative mortality in this group nor second reintervention. Hachiro and colleagues reported 12 reoperations on the tricuspid valve, their mean age was 17 years, and six patients underwent tricuspid valve replacement.[15]

Hospital mortality was 16.7%, and three patients required another reoperation for a failed tricuspid valve repair. Prophylactic tricuspid valve repair was recommended during the primary repair of TOF to decrease the reoperation rate.[2]

VSD repair was the most common indication for reoperation in our series (55%). Lower rates were reported in other series.[13, 16] The rates of residual VSD may differ significantly in the published series because of the variability of the methods of diagnosis. Spontaneous closure of residual VSD was reported.[16]

In our study, we reported 14 patients with recurrent or residual RVOTO and had RVOT resection. Conservative management was reported for cases with asymptomatic and mild RVOTO.[17]

In summary, reoperation after TOF repair is common, and VSD was the most common indication in our series. The outcomes of reoperation are good with low operative mortality; moreover, we did not report further reoperations during a one-year follow-up.

Study limitations:

The study is a single-center experience, and the indications for reoperations may differ significantly according to the centers because of the different surgical experiences. The study included one group of patients who had reoperation, and studying the risk factors for reoperations in this number was not feasible. However, the study highlighted our experience in the management of patients who needed reoperations after primary TOF repair.

## Conclusion

A residual ventricular septal defect is a common indication for reoperation after the primary repair of tetralogy of Fallot. The results of reoperations are good with the accepted incidence of postoperative morbidity and mortality. Refining the surgical technique during the primary repair may help to decrease the rate of reoperation.

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