

## Reoperations after total correction of tetralogy of Fallot

*Fallot tetralojisi onarımı sonrası yeniden ameliyat gerektiren olgular*

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**Background:** Although the immediate results of definitive repair for tetralogy of Fallot (TOF) are excellent, it is known that some patients require a second or even third operation. The aim of this study was to analyze the indications, surgical procedures, and clinical outcomes of patients undergoing reoperation.

**Methods:** Between 1985 and 2003, 211 patients underwent corrective repair for TOF in our clinic. Of these, 12 patients (%5.6; 7 females, 5 males; mean age 14.4±5.6 years; range 6 to 25 years) required reoperation. In all the patients, indication for reoperation was residual ventricular septal defect (VSD). Additionally, five patients had severe right ventricular outflow tract (RVOT) obstruction, and one patient had severe pulmonary regurgitation. At the reoperation, a new patch was placed to close the residual VSD in seven patients, and the former patch was repaired with pledgeted sutures in the remaining five. A pulmonary xenograft was implanted in the patient with severe pulmonary valve insufficiency. The mean follow-up after reoperation was 48.4±9 months.

**Results:** There was no operative mortality. The only perioperative complication was injury to the right ventricle during sternotomy in one patient. One patient underwent a third operation for recurrent VSD due to infective endocarditis. Functional status was NYHA class I in eight patients, and class II in three patients. On final evaluations, there was no residual VSD or pulmonary regurgitation. The only mortality occurred due to a massive cerebral hemorrhage in the patient who underwent a third operation.

**Conclusion:** For patients presenting with residual VSD or RVOT problems after correction of TOF, a reoperation should be considered in case progressive right ventricular failure and clinical deterioration develop. Reoperations are effective in relief of residual VSDs and RVOT pathologies and offer good mid-term results.

**Key words:** Aortic valve insufficiency; heart septal defects, ventricular/surgery; postoperative complications; pulmonary valve insufficiency/etiology; reoperation; tetralogy of Fallot/surgery; ventricular outflow obstruction/surgery.

**Amaç:** Fallot tetralojisi (TOF) için uygulanan radikal düzeltme ameliyatlarının erken dönem sonuçları çok iyi olmakla birlikte, bazı hastalarda ikinci, hatta üçüncü kez ameliyat gerektiği bilinmektedir. Bu çalışmada, ameliyat tekrarı gerektiren endikasyonlar, uygulanan prosedürler ve tekrar ameliyat edilen hastalardaki klinik sonuçlar değerlendirildi.

**Çalışma planı:** Kliniğimizde 1985-2003 tarihleri arasında 211 hastaya TOF tanısı ile radikal düzeltme ameliyatı uygulandı. Bu hastaların 12'sinde (%5.6; 7 kadın, 5 erkek; ort. yaş 14.4±5.6; dağılım 6-25) yeniden ameliyat gerekti. Tüm hastalarda yeniden ameliyat endikasyonu rezidüel ventriküler septal defekt (VSD) idi. Ek olarak, beş hastada ciddi sağ ventrikül çıkım yolu (RVOT) obstrüksiyonu, bir hastada ciddi pulmoner kapak yetersizliği vardı. Rezidüel VSD'yi kapatmak için yedi hastada yeni bir yama kullanıldı; beş hastada ilk ameliyatta konmuş olan yama pledgetli dikişlerle onarıldı. Pulmoner yetmezliği olan hastaya ksenograft yerleştirildi. Hastaların ikinci ameliyattan sonra ortalama takip süresi 48.4±9 aydı.

**Bulgular:** Ameliyat sırasında ölen hasta olmadı. Bir hastada sternotomi sırasında sağ ventrikül yaralanması dışında komplikasyon gelişmedi. İnfektif endokardite bağlı olarak gelişen tekrarlayan VSD nedeniyle bir hasta üçüncü defa ameliyata alındı. Sekiz hasta NYHA sınıf I, üç hasta sınıf II fonksiyonel kapasitede idi. Hiçbir olguda rezidüel VSD veya pulmoner yetersizlik saptanmadı. Üçüncü ameliyat uygulanan hasta yoğun serebral kanama nedeniyle kaybedildi.

**Sonuç:** Total düzeltme ameliyatı sonrası rezidüel VSD ve RVOT patolojisi saptanan hastalarda sağ ventrikül yetersizliği ve klinik bozulma saptanırsa, ikinci bir ameliyat planlanmalıdır. Tekrar ameliyat ile rezidüel VSD ve RVOT patolojisi düzeltilen hastaların orta dönem sonuçları tatminkardır.

**Anahtar sözcükler:** Aort kapağı yetersizliği; kalp septal defekti, ventriküler/cerrahi; ameliyat sonrası komplikasyon; pulmoner kapak yetersizliği; yeniden ameliyat; Fallot tetralojisi/cerrahi; ventrikül çıkım yolu obstrüksiyonu/cerrahi.

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With the refinement in surgical techniques, radical correction of tetralogy of Fallot (TOF) has been performed in increasing frequency.<sup>[1-3]</sup> Even though numerous reports have demonstrated excellent results after surgical correction of TOF, these patients are at risk for long-term morbidity such as life-threatening arrhythmias, residual ventricular septal defect (VSD), right ventricular outflow tract (RVOT) obstruction, tricuspid or pulmonary valve regurgitation, and infective endocarditis.<sup>[4]</sup> These serious late complications can adversely affect late survival and some may require reoperation. Overall reoperation rates reported range from 3.3% to 16.5%.<sup>[5,6]</sup> The most frequent indications for reoperation are residual VSD, residual RVOT obstruction, pulmonary regurgitation, severe tricuspid valve regurgitation, stenosis of the pulmonary artery or its branches.

The aim of this study was to analyze our indications, surgical procedures, and clinical outcomes of patients undergoing reoperation after surgical correction of TOF.

## PATIENTS AND METHODS

Between 1985 and 2003, 211 patients (124 males, 87 females; mean age 11.5±9.2 years; range 1 to 49 years) underwent total correction for TOF in our institution. Reoperation rate was 5.6% with 12 patients (7 females, 5 males). The mean age at the time of reoperation was 14.4±5.6 years (range 6 to 25 years). The mean duration from the initial surgery to reoperation was 11.7±24.3 months. Indications for reoperation were clinical deterioration with objective signs of right ventricular dysfunction and significant left to right shunt ( $Q_p/Q_s > 1.5$ ). The most frequent indication for reoperation was residual VSD. Additionally, five patients had severe RVOT obstruction (with a systolic gradient above 30 mmHg), and one patient had severe pulmonary regurgitation. Another six patients were followed-up with periodic echocardiographic studies for moderate pulmonary stenosis, four patients for moderate pulmonary regurgitation, and three asymptomatic patients with residual ventricular septal defect with a  $Q_p/Q_s$  ratio less than 1.5.

The most prominent symptoms and signs in these 12 patients were fatigue, hepatomegaly, pleural effusion, and ascites due to progressive right ventricular failure. Eight patients were in New York Heart Association (NYHA) functional class I-II, three in class III, and one in IV. Echocardiography and cardiac catheterization were performed in all the patients during evaluations for reoperation. In one patient, septal patch was intact, but there was another VSD that remained undetected at the initial operation. At the initial operation, a synthetic patch (Dacron) was used to close the VSD in all the patients. Multiple single pledgeted sutures at the posteroinferior rim of the VSD and continuous sutures in the circumference of the VSD were used in nine

patients. In three patients, the patch was anchored using only single pledgeted sutures. Infundibular muscular resection was performed in all the patients, with an addition of pulmonary valvulotomy in five patients to relieve RVOT obstruction. Transannular pericardial patch enlargement was performed in 10 cases, while only a right ventricular incision and enlargement were used in two patients (Table 1).

**Surgical technique.** Cardiopulmonary bypass (CPB) with moderate hypothermia (24-28 °C) was used in all the operations. Arterial cannulation was established via the ascending aorta, except in one patient who required emergent femoral cannulation due to the right ventricular injury during sternotomy. Intermittent antegrade hypothermic crystalloid or blood cardioplegia were used for myocardial protection.

In eight patients, the leak was at the posterosuperior or posteroinferior area of the septal patch. For repair of the residual VSD, a new patch was sutured using separated stitches in seven patients, and the formerly placed patch was repaired with pledgeted sutures in the remaining five patients. For the relief of RVOT obstruction, a new pericardial patch extending to the pulmonary bifurcation was used in three patients. In one patient, the formerly placed right ventricular patch was excised and replaced by a larger one. In another, a new patch was inserted transannularly (Table 1). A xenograft was inserted between the right ventricle and pulmonary artery in the patient presenting with pulmonary regurgitation. The average cross-clamping time was 78.6±25 minutes, and the mean CPB time was 103.4±34.6 minutes. The mean follow-up period was 48.4 months.

## RESULTS

There was no operative mortality. The only serious complication was the injury to the right ventricle during sternal re-entry in one patient. Three patients (24.9%) required inotropic support in the early postoperative period. Intraaortic balloon counter pulsation (IABP) was used in the patient who underwent pulmonary xenograft implantation. One patient (8.3%) had transient AV-block and required a temporary pacemaker during the early postoperative period. One patient (8.3%) developed infection at the site of the sternal incision. Bilateral pneumothorax occurred in one patient, which was treated by pleural tube insertion. The mean intensive care unit stay was 4.2±6.3 days and the mean hospitalization was 16.3±9.1 days. All the patients were in sinus rhythm at the time of discharge.

Infective endocarditis developed in one patient four months after the reoperation. In the follow-up of this patient, a residual VSD was detected and clinical deterioration ensued. The patient underwent a third operation

**Table 1. Patients' data on the initial surgeries and reoperations**

Patient	Initial procedure	Indication	The type of reoperation
1	IMR, TAPE, PV	Residual VSD	VSD closure
2	IMR, TAPE	Residual VSD	VSD closure
3	IMR, TAPE, PV	Residual VSD	VSD closure
4	IMR, TAPE	Residual VSD	VSD closure
5	IMR, TAPE	Residual VSD	VSD closure
6	IMR, TAPE	Residual VSD	VSD closure
7	IMR, TAPE	Residual VSD	VSD closure
8	IMR, TAPE	RVOTO	Extension of incision
		Residual VSD	VSD closure
		RVOTO	Extension of incision
9	IMR, TAPE	Residual VSD	VSD closure
		RVOTO	Extension of incision
10	IMR, PV, patch closure of right ventriculotomy	Residual VSD	VSD closure
		RVOTO	IMR, infundibular new patch
11	IMR, PV, patch closure of right ventriculotomy	Residual VSD	VSD closure
		RVOTO	TAP
12	IMR, PV, TAPE	Residual VSD	VSD closure
		PI	RV-PA valved conduit

IMR: Infundibular muscle resection; PA: Pulmonary artery; PI: Pulmonary insufficiency; PV: Pulmonary valvulotomy; RV: Right ventricle; RVOTO: Right ventricle outflow tract obstruction; TAPE: Transannular patch enlargement; VSD: Ventricular septal defect.

under antibiotic treatment via a median sternotomy under CPB. There were infective vegetations on the ventricular septal patch, which required removal of the patch. Ventricular septal defect was closed using a new Dacron patch. This patient stayed in the intensive care unit for 15 days and was taken to the ward on the 19th postoperative day. He developed a massive intracerebral hemorrhage in the occipital region and died on the 35th postoperative day.

At the end of the follow-up period, eight patients were in NYHA class I, and three patients were in class II. All the surviving patients were monitored by routine echocardiographic evaluations. The mean pressure gradient at the right ventricular outflow tract was  $22 \pm 10.3$  mmHg (range 15 to 47 mmHg). Three patients had mild tricuspid regurgitation. There was no residual VSD or pulmonary regurgitation.

## DISCUSSION

Long-term results and life quality after total correction have increased since the first operation for TOF. However, as the number of corrected patients increase reoperation rate is also on the incline. Timely reoperation of these patients before cardiac and pulmonary dysfunctions ensue may prevent some postoperative problems.<sup>[7]</sup> Yet, the timing of the reoperation is still controversial.<sup>[8]</sup> A reoperation should be considered if symptoms of progressive right ventricular failure and clinical deterioration develop. Residual VSDs, RVOT obstructions and pulmonary regurgitation are serious late complications that may adversely affect late sur-

vival. Some residual hemodynamic problems can be well-tolerated for years. Abe et al.<sup>[9]</sup> reported residual VSDs as the most frequent indication for reoperation. A residual VSD with a Qp/Qs ratio greater than 1.5 was the most frequent indication for reoperation in our patients, followed by RVOT-related problems. In eight patients, a leak was detected at the posterosuperior or posteroinferior area of the septal patch. This was attributed to more superficial insertion of sutures in these areas in order to avoid any injury to neighbouring conduction tissue. For closure of the residual VSD, repair with single pledgeted sutures was preferred. Castaneda et al.<sup>[10]</sup> reported that repair of the leak area with a new patch would be more suitable than primary repair. The small size of the residual VSD and the presence of a well-developed scar tissue make primary repair more feasible. In seven patients, a new patch was inserted with single pledgeted sutures for the repair of the residual VSD, while the formerly placed patch was repaired with pledgeted sutures in the remaining five patients.

Active prosthetic patch infection is a rare, but serious condition, requiring the replacement of the previously implanted patch. Abscess formation may occur at the tricuspid annulus involving the septal patch, and the leaflet and/or annulus may require reconstruction using an autologous pericardial patch.

In recent years, RVOT problems were reported to be the most frequent indication for reoperation,<sup>[4,6,7]</sup> although the residual VSD was the main indication in our patients. Injudicious assessment of the size or posi-

tion of the transannular patch at the initial operation, angulation of the left pulmonary artery, and the compression of the hypertrophied right ventricle on the left pulmonary artery may result in pulmonary obstruction. Oechslin et al.<sup>[6]</sup> and Faidutti et al.<sup>[7]</sup> reported that restenosis occurred mostly at the pulmonary artery bifurcation or the left main pulmonary artery. A careful assessment of anatomy and the use of an appropriately-sized patch for outflow enlargement at the initial operation, or insertion of a second patch in this area may reduce the risk for reoperation.<sup>[7]</sup> Pulmonary regurgitation and right ventricular dilatation may develop gradually with time in one-thirds of patients undergoing transannular repair. However, this is generally well-tolerated for long years unless there is additional pathology. For this reason, it is not always easy to decide in favor of reintervention in patients with pulmonary regurgitation. Despite arrhythmias and echocardiographically detected right ventricular dilatation, patients may feel well for a long period, making it difficult to decide to perform pulmonary valve replacement.<sup>[11]</sup> Kirklin et al.<sup>[12]</sup> reported that pulmonary insufficiency was well-tolerated for years and required reoperation only in the presence of a concurrent obstruction. Finck et al.<sup>[13]</sup> advocated that the development of tricuspid insufficiency be an indication for pulmonary valve replacement. If a patient with a residual VSD and tricuspid regurgitation develops pulmonary regurgitation and right ventricular failure within a short time, reoperation should be performed as soon as possible. For the repair of pulmonary regurgitation, aortic allografts should be preferred due to their long-term durability. If it is necessary to use a prosthetic valve, a bioprosthetic valve should be preferred rather than a mechanical valve.<sup>[14]</sup>

Reoperations should be considered in patients presenting with a residual VSD and RVOT pathologies after corrective TOF procedures, if symptoms of progressive right ventricular failure and clinical deterioration develop. These reoperations are effective in relief of residual VSDs and RVOT obstructions, and offers good mid-term results.

## REFERENCES

1. Starnes VA, Luciani GB, Latter DA, Griffin ML. Current surgical management of tetralogy of Fallot. *Ann Thorac Surg* 1994;58:211-5.
2. Fraser CD Jr, McKenzie ED, Cooley DA. Tetralogy of Fallot: surgical management individualized to the patient. *Ann Thorac Surg* 2001;71:1556-61.
3. Murphy JG, Gersh BJ, Mair DD, Fuster V, McGoon MD, Ilstrup DM, et al. Long-term outcome in patients undergoing surgical repair of tetralogy of Fallot. *N Engl J Med* 1993;329:593-9.
4. Sugita T, Ueda Y, Matsumoto M, Ogino H, Sakakibara Y, Matsuyama K. Repeated procedure after radical surgery for tetralogy of Fallot. *Ann Thorac Surg* 2000;70:1507-10.
5. Pome G, Rossi C, Colucci V, Passini L, Morello M, Taglieri C, et al. Late reoperations after repair of tetralogy of Fallot. *Eur J Cardiothorac Surg* 1992;6:31-5.
6. Oechslin EN, Harrison DA, Harris L, Downar E, Webb GD, Siu SS, et al. Reoperation in adults with repair of tetralogy of fallot: indications and outcomes. *J Thorac Cardiovasc Surg* 1999;118:245-51.
7. Faidutti B, Christenson JT, Beghetti M, Friedli B, Kalangos A. How to diminish reoperation rates after initial repair of tetralogy of Fallot? *Ann Thorac Surg* 2002;73:96-101.
8. Ilbawi MN, Idriss FS, DeLeon SY, Muster AJ, Gidding SS, Berry TE, et al. Factors that exaggerate the deleterious effects of pulmonary insufficiency on the right ventricle after tetralogy repair. Surgical implications. *J Thorac Cardiovasc Surg* 1987;93:36-44.
9. Abe T, Morishita K, Nakanishi K, Kamada K, Komatsu S. Reoperation after corrective surgery for tetralogy of Fallot. *Kyobu Geka* 1994;47:605-11. [Abstract]
10. Castaneda AR, Sade RM, Lamberti J, Nicoloff DM. Reoperation for residual defects after repair of tetralogy of Fallot. *Surgery* 1974;76:1010-7.
11. de Ruijter FT, Weenink I, Hitchcock FJ, Meijboom EJ, Bennink GB. Right ventricular dysfunction and pulmonary valve replacement after correction of tetralogy of Fallot. *Ann Thorac Surg* 2002;73:1794-800.
12. Kirklin JK, Kirklin JW, Blackstone EH, Milano A, Pacifico AD. Effect of transannular patching on outcome after repair of tetralogy of Fallot. *Ann Thorac Surg* 1989;48:783-91.
13. Finck SJ, Puga FJ, Danielson GK. Pulmonary valve insertion during reoperation for tetralogy of Fallot. *Ann Thorac Surg* 1988;45:610-3.
14. Kawachi Y, Masuda M, Tominaga R, Tokunaga K. Comparative study between St. Jude Medical and bioprosthetic valves in the right side of the heart. *Jpn Circ J* 1991;55:553-62.