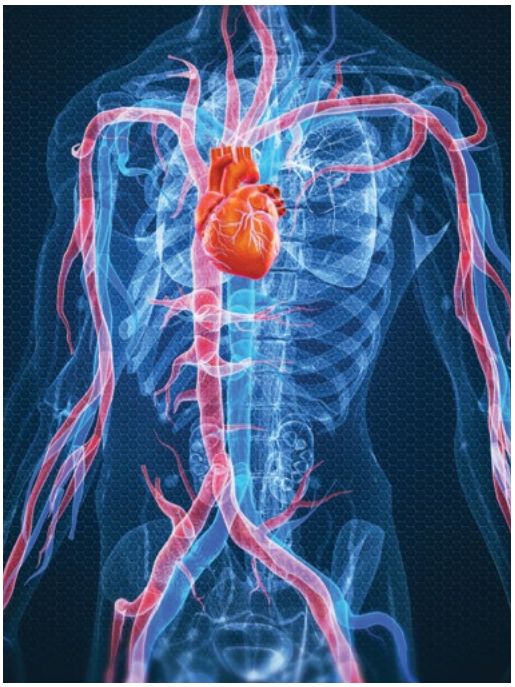
Tetralogy of Fallot in adults



Vishva A Wijesekera

Background
Following surgical repair in infancy, a high proportion of children born with tetralogy of Fallot are surviving into adulthood, and it is important that these patients are monitored by an adult congenital heart disease specialist for problems and complications that can occur in the adult patient.

Objective
To provide an overview on the management of adult patients with repaired tetralogy of Fallot and emphasise the need for specialist follow-up.

Discussion
Following surgical repair of tetralogy of Fallot, it is important to have lifelong surveillance in adulthood for complications such as pulmonary valve dysfunction. Modern imaging modalities have helped with monitoring and the early detection of problems. Cardiac surgery has been refined over the years, leading to improved longevity. Over the past 23 years, percutaneous interventions have been developed to deal with valve complications and the results have been promising. Healthy behaviour, such as regular exercise, and behaviours to minimise the risk of endocarditis should be encouraged. Regular follow-up with an adult congenital heart disease specialist is important. Patients wishing to undertake a pregnancy should be supervised through a high-risk pregnancy clinic.

AN INCREASING NUMBER OF CHILDREN born with congenital heart disease are surviving into adulthood in the modern era. Tetralogy of Fallot (TOF) is one such congenital cardiac anomaly. Over the past 50 years, much progress has been made in its surgical treatment, leading to most children born with this condition surviving into adulthood following successful surgical repair in childhood. Patients with repaired TOF should be under regular review by a cardiologist familiar with congenital heart disease. It would be beneficial for general practitioners to have an understanding of the condition as it progresses in adulthood, what problems might develop and what treatment options are available

Aim

The aim of this paper is to provide an overview on the management of the adult patient with previous TOF repair. It is hoped that this article will help the reader appreciate the importance of patients with repaired TOF having lifelong follow-up to prevent and treat complications that can arise in adulthood.

Discussion

Tetralogy of Fallot accounts for 4.4% of congenital heart defects in infancy,[1] and occurs at a frequency of five per 10,000 live births, with a slight male predominance.[2] Historically, in the 1970s and 1980s, total surgical repair occurred at around the age of four years; however, in contemporary practice with newer surgical techniques and advances in perioperative care, total repair is performed at an age of 6–12 months. TOF was first described in 1673 by the Danish anatomist, Nicolas Steno and, in 1888, its anatomy was more extensively documented by the French physician, Etienne-Louis Fallot.[3] In 1924, Maude Abbott named the condition 'tetralogy of Fallot'. The estimated 30-year survival is up to 91% in the current era.[4] The recurrence rate from parent to child has been estimated at 1.2%. In 15% of patients, TOF is associated with DiGeorge syndrome (microdeletion of chromosome 22q11).[5] The first surgical repair for TOF occurred in 1954 with the advent of cardiopulmonary bypass surgery.

There are four anatomical features that define TOF:

- stenosis of the subpulmonary infundibulum, which is the key feature that defines TOF and can be associated with pulmonary valve stenosis, supravalvular stenosis and branch pulmonary artery stenoses
- ventricular septal defect (VSD)
- aortic override, where the aortic valve lies over the VSD (if >50% of the aortic valve lies within the right ventricular [RV] side, this is termed a 'double outlet right ventricle')
- RV hypertrophy.[6]

In unoperated patients, survival was poor due to the morbidity associated with the condition, and 25% died within the first year of life and 40% prior to the age of three years.[7] Unoperated patients often developed progressive cyanosis, exercise intolerance, arrhythmias, thromboembolism or cerebral abscesses.

Surgery for TOF involves closure of the VSD, relieving any obstruction in the pulmonary outflow tract (which might involve RV outflow tract [RVOT] resection, pulmonary valve repair, branch pulmonary artery augmentation and/or a valved conduit between the RV and pulmonary artery).

Sometimes it is necessary to first perform a palliative procedure (eg a subclavian artery to pulmonary artery shunt) to improve pulmonary blood flow and therefore growth of the pulmonary tree prior to performing complete surgical repair of TOF. Even though the palliative shunt is taken down at the time of complete repair, it can lead to reduced blood pressure readings on the ipsilateral side of the shunt due to attenuation of the transmitted systolic pulse wave. From a practical perspective, this means that in a patient who has previously had, for instance, a previous subclavian shunt on the left side, the left arm systolic blood pressure might provide a falsely low reading that is not representative of the central aortic systolic pressure.

When the patient with repaired TOF reaches adulthood, it is important that the physician monitors the patient for the following possible complications:

- Pulmonary valve dysfunction – most commonly, pulmonary valve surgery in infancy leads to pulmonary regurgitation (PR),[8] particularly if a transannular patch is used. Pulmonary valve stenosis can also recur and can be subvalvular, valvular or supravalvular. Severe PR can occur after pulmonary valve repair even in the absence of a transannular patch. Severe PR is often tolerated well for many years, sometimes decades, and its presence does not necessarily imply further surgery is imminent.
- Residual VSDs – these can occur following initial surgery due to surgical patch dehiscence.
- Ventricular arrhythmias – these can occur particularly if surgical access during the original operation was through a ventriculotomy. In recognition of this problem, modern surgical repair avoids a ventriculotomy and, instead, a transatrial or transpulmonary approach is used. The prevalence of ventricular arrhythmias is estimated at 15%, and this increases significantly after the age of 45 years.[9]
- Dilatation and dysfunction of the RV – these are due to the pressure and volume load that occurs from pulmonary valve dysfunction. Right bundle branch block is common in these patients, and leads to RV electromechanical dyssynchrony.[10,11] In addition, RV dilatation can cause tricuspid annular dilatation and therefore tricuspid regurgitation.
- Recurrent RV outflow tract stenosis and aneurysm formation.
- Branch pulmonary artery stenosis.
- Left-sided heart disease, such as left ventricular systolic dysfunction[12] (LVSD) and dilatation – this might be due to left ventricular fibrosis that occurred in infancy, where the total repair was performed late and the ventricle was subject to a prolonged period of hypoxia and volume load due to the right to left shunt. LVSD might also be the result of chronic RV dilatation and dysfunction and septal dyssynchrony. In one study of adult repaired TOF patients, the frequency of LVSD was 30%.[13]
- Aortic root dilatation – some studies report that aortic dilatation is present in up to 50% of patients.[14] Although aortic dissection is considered rare in this group of patients, expert consensus dictates intervention at an ascending aortic size of 55 mm or greater.[15]
- Aortic regurgitation – this can be related to a dilated aortic root causing a coaptation defect. It can also occur due to leaflet abnormality related to the lack of leaflet support that existed prior to closure of the VSD.
- Atrial arrhythmias – these are often a result of atrial scar due to previous surgery, RV dysfunction and tricuspid regurgitation leading to atrial dilatation. In addition to anti-arrhythmic therapy, sophisticated electrophysiological procedures can be used to treat such problems.

Pulmonary valve replacement

Generally, if a patient has symptoms (dyspnoea, palpitations, exercise intolerance) due to severe PR, valve replacement is indicated. In asymptomatic patients with severe PR, the aim is to delay surgical intervention for as long as possible to reduce the total number of lifetime valve surgeries. The RV volume is most accurately assessed by cardiac magnetic resonance imaging (MRI), and once the RV size is greater than 150–160 mL/m^2 (RV volume indexed to body surface area), intervention is indicated.[16] It has been found that it is best to avoid allowing the RV to dilate beyond a dimension of 170–180 mL/m^2, because above these dimensions the RV might not regress following correction of the PR.[17] Cardiac MRI is the gold standard imaging modality for assessing the RV, but in patients who cannot have an MRI scan, functional cardiac computed tomography can be done to obtain RV volume measurements.

In the case of RVOT stenosis or pulmonary valve stenosis, intervention is indicated once the RV systolic pressure is greater than two-thirds of the corresponding left ventricular systolic pressure.

Electrophysiological procedures

When cardiac arrhythmias are present (eg non-sustained ventricular tachycardia or even difficult-to-control atrial tachyarrhythmias), if there is a coexisting haemodynamically significant lesion involving the pulmonary or tricuspid valve (eg severe PR), this should be corrected first. Catheter-based radiofrequency ablation of atrial and ventricular arrhythmias is often done and primary prevention implantable cardioverter defibrillators (ICDs) are considered in patients who otherwise meet standard qualifying criteria.[18]

Percutaneous interventions

In the past 23 years, numerous advances in percutaneous interventions have allowed patients to avoid thoracotomy. Branch pulmonary artery stenoses are often amenable to percutaneous balloon angioplasty and stent placement. Patients who have had a previous pulmonary valve replacement can often have a percutaneous pulmonary valve placed within the existing dysfunctional pulmonary valve. This was first done with the Medtronic Melody transcatheter valve in the pulmonary position in 2000.[19] In 2006, the first percutaneous Edwards SAPIEN valve was implanted in the pulmonary position.[20] There are a number of new percutaneous valves currently under development (VenusP-Valve [Venus MedTech, Shanghai, China], Medtronic Harmony TPV [Medtronic, Minneapolis, MN, USA]) that, in future, will allow placement of a pulmonary valve within the native pulmonary outflow tract[21] and, once this is established, this will greatly expand the patient population that can be treated percutaneously instead of requiring further sternotomies. Current results with the Melody valve and Edwards SAPIEN valve have been very encouraging and both have proven to be safe and effective.[22]

In addition to percutaneous pulmonary valve and branch pulmonary artery interventions, successful percutaneous mitral valve edge-to-edge repair has been reported.[23]

Residual VSDs can occur, particularly if there is patch dehiscence at the site of the previous VSD repair. This often requires reoperation with patch repair; however, percutaneous closure of the VSD might also be possible in certain cases.

Exercise restriction

Exercise restriction is not required in patients with no significant residual lesions, preserved biventricular function, no aortic root dilatation and a relatively short QRS duration.[24] If there is a history of life-threatening arrhythmias, such as non-sustained ventricular tachycardia, significant exercise restriction is advised. If there are haemodynamically significant lesions, not meeting thresholds for surgical intervention, some exercise restriction might also be necessary. A recent detailed overview on exercise prescription in congenital heart disease by Tran et al[25] clearly outlines an approach for this; in summary, it states that the exercise program should be done in conjunction with a congenital heart disease specialist, with pre-evaluation cardiopulmonary exercise testing and an assessment of congenital heart disease risk (ie high, medium, low) based on the severity of structural heart disease, implementation of the exercise program and ongoing review for any signs of clinical deterioration. In that review document, specific heart rate and weightlifting targets are mentioned corresponding to the level of congenital heart disease risk.[25]

Pregnancy

In patients with repaired TOF, the risk of pregnancy depends on the underlying haemodynamics. In patients without significant RVOT stenosis, and without severe PR or RV dysfunction, the risk approaches that of the general population.[26] In patients with significant valvular lesions or RV dysfunction, the volume load can lead to RV failure and arrhythmias. All patients should have prepregnancy counselling and should be monitored by an adult congenital heart disease cardiologist. Pregnancy and delivery should be overseen by a high-risk pregnancy clinic that is experienced in managing women with congenital heart disease.[26]

Antibiotic prophylaxis

Infective endocarditis is an important complication in patients with repaired TOF. This most commonly involves the pulmonary valve, particularly if there has been a prosthetic valve implanted (biological valve or homograft/allograft). Rarely, infection might involve the previous VSD patch repair.[27] All patients should be strongly encouraged to have regular dental reviews to minimise the risk of endocarditis. In addition, in patients with prosthetic material or residual shunts, antibiotic prophylaxis is recommended for any invasive procedures. Detailed guidelines on antibiotic prophylaxis for the prevention of endocarditis is available through Therapeutic Guidelines.[28]

Conclusion

In the modern era, the survival and prognosis of patients with repaired TOF is good, with greater than 90–95% survival 25 years after repair.[29] All patients should have lifetime follow-up with a congenital heart disease specialist aiming to identify and manage long-term complications. Management is generally in conjunction with a team of specialists familiar with congenital heart disease, including congenital heart disease specialists, electrophysiologists, structural interventionalists and, in women of child bearing age, a high-risk pregnancy unit. It is important that general practitioners who encounter these patients have a general understanding of the disease process and encourage these young, often asymptomatic, patients to have regular follow-up with the congenital heart disease team.

Key points

- Survival into adulthood is very good in patients with surgically repaired TOF.
- These patients require lifelong follow-up for early identification of complications, and this should be in conjunction with an adult congenital heart disease unit.
- Repeat cardiac interventions, both surgical and non-surgical, are often necessary.
- Good healthy practices, such as regular exercise to maintain cardiovascular fitness and dental hygiene to minimise endocarditis, should be encouraged.
- Pregnancy and delivery in female patients should be supervised through a high-risk pregnancy clinic.

Author

Vishva A Wijesekera MBChB, FRACP, Adult Congenital Heart Disease Specialist, Department of Cardiology, The Prince Charles Hospital, Brisbane, Qld

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Correspondence to:
vwijesekera@outlook.com

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correspondence **ajgp@racgp.org.au**