



ORIGINAL ARTICLE

# Mid-term follow-up of pulmonary regurgitation in repaired asymptomatic TOF patients by transannular patch: A prospective cardiac MRI study



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## KEYWORDS

Pulmonary regurgitation;  
Cardiac MRI;  
TOF

**Abstract Objective:** The long-term outcome of Tetralogy of Fallot (TOF) surgical repair in developing countries is still unknown. Therefore the aim of the study was the quantification of pulmonary regurgitation (PR) and right ventricular functions using cardiac magnetic resonance (CMR) in order to follow up midterm post transannular patch repair of asymptomatic TOF patients.

**Methods:** We prospectively studied 37 asymptomatic corrected TOF patients (aged 18 years or less), aged at surgery was of median, min/max of (19, 8/48 months). Cardiac functions were assessed using routine steady state free precession techniques. PR quantification was performed using the routine velocity encoding phase contrast in the main pulmonary artery.

**Results:** Four patients had mild PR, 26 had moderate PR and seven had severe PR, with a median value of PR% in CMR amounting to 29% (max: 75% and min: 13%). Indexed right ventricle end-diastolic volume amounted to (mean  $\pm$  SD)  $130 \pm 38$  ml, and indexed right ventricle end-systolic volume amounted to  $63 \pm 26$  ml.

**Conclusion:** Accurate quantitative assessment of PR in the mid and long-term course of TOF patients is paramount. CMR has to be introduced as a new modality in Egypt in the follow up course of asymptomatic TOF patients.

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## 1. Introduction

Tetralogy of Fallot (TOF) is the most common congenital cyanotic heart disease. Correction of TOF can be performed with low mortality; therefore a growing population of postsurgical repair TOF patients survives into adulthood (1).

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Transannular patch repair is one of the surgical techniques performed to relieve the stenosis of the right ventricular outflow tract (RVOT) or pulmonary annulus, an incision through the pulmonary valve (PV) to open the RVOT. A patch is then used to increase the diameter of the outflow region and the main pulmonary artery (2).

Among the most common complications of TOF surgical repair is pulmonary regurgitation (PR). It remains the most common postrepair lesion influencing earlier morbidities (2,3).

Other complications might include, dilated right ventricle (RV), inter-ventricular interactions with left ventricle (LV) dysfunction (4), pulmonary artery aneurysm or peripheral stenosis of the pulmonary arteries. It can also be associated with exercise intolerance, atrial and ventricular arrhythmia, and sudden cardiac death (5).

Moreover, many studies reported improved RV volumes and function, improved exercise capacity, stabilization of QRS duration after pulmonary valve replacement (PVR). However, a question of debate remains with the optimal timing of PVR in patients with corrected TOF (6).

With the complexity of RV geometry and difficult echocardiographic window of the pulmonary valve, 2D and Doppler echocardiographic measures for quantification of PR and RV function could not be standardized (7).

The long-term outcome of corrected TOF surgery in developing countries is unknown. This might be due to lack of guidelines, recording results, and/or introducing new modalities such as the usage of cardiac magnetic resonance (CMR).

Therefore, it is paramount to follow up those patients postoperatively in the short and long term, and through accurately quantifying PR, cardiac volumes and functions. CMR is now considered the gold standard for non-invasive quantification of PR and RV volumes (7). D'Udekem et al. (5) stated that every TOF should at least have one CMR visit with pulmonary angiography to determine the pulmonary tree anatomy and morphology.

Hence, this study is the first CMR study showing PR and cardiac function in surgically corrected asymptomatic TOF patients using the transannular patch technique in a developing country.

## 2. Material and methods

The study was approved by Cairo University's Review Board for Human Research and Ethics. As a routine work protocol in educational hospitals a written informed consent was always obtained from the accompanying parents, according to our institute's guidelines.

### 2.1. Subjects

We prospectively studied 37 asymptomatic, clinically stable patients (aged 18 years or less) (Table 1), who had corrective intra-cardiac repair for TOF. They were referred to our postoperative outpatient clinic in Cairo University Children's Hospital, for regular visits at least once a year.

All patients had transannular patch augmentation of the right ventricular outflow tract in the Cairo University Hospitals. A prior palliative procedure (modified Blalock Taussig (MBT)) shunt was performed in 2 patients. Patients underwent a trans-thoracic echocardiogram for study purposes. Both the

**Table 1** General demographic and clinical patient characteristics.

Parameters	Cases (n = 37)
Gender (n, %)	
Males	21 (57)
Females	16 (43)
Age at examination (years) (Mean ± SD)	9.3 ± 4.8
Age at surgery (month) (Median, max, min)	24 (8–48)
BSA (m <sup>2</sup> ) (Mean ± SD)	0.9 ± 0.31
Increased C/T ratio (n, %)	32 (86)
QRS duration (ms) (Mean ± SD)	126.8 ± 19.8
RBBB (n, %)	20 (54)
Previous palliative surgery (MBT shunt) (n, %)	2 (5.4)

n: frequency, %: percentage, SD: standard deviation, NYHA: New York Heart Association, C/T ratio: cardiothoracic ratio, RBBB: right bundle branch block, and MBT: modified Blalock Taussig.

Echo and CMR scans were performed within 3 months of each other between December 2011 and April 2013.

### 2.2. Inclusion criteria

- TOF patients with moderate to severe pulmonary regurgitation diagnosed using echo without symptoms of right ventricular dysfunction or NYHA (I or II).
- Age at operation (mid and long term) following the repair.
- Time of postoperative follow up.
- ECG: prolonged QRS duration (> 120 ms).

### 2.3. Exclusion criteria

- TOF patients with severe right ventricular dysfunction.
- Uncooperative patients.
- TOF patients who developed major or early postoperative complications.
- TOF patients who developed arrhythmias.
- TOF patients with pacemakers.
- Major or severe congenital anomalies.
- Echo findings including:
  - Residual shunts.
  - Peripheral pulmonary artery stenosis.
- Short term follow-up of patients developing PR within 30 days postoperatively.

### 2.4. CMR

#### 2.4.1. Patient preparation prior to CMR examination

In all cases, an expert in congenital heart disease CMR (A.K.) spoke to patients and their parents or accompanying adults before the CMR examination. During this visit, the expert explained the CMR examination, took the history, checked for pacemakers or metal in the patients' body, informed the

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