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Types of Surgical Repair and Outcome in Patients with Tetralogy of Fallot: Experience from A Single Center in Saudi Arabia

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ABSTRACT

Background: Congenital heart disease is the most prevalent form of primary congenital disability in newborns and is the leading cause of death in children with congenital malformations. It occurs in approximately 0.8% of live births. With advances in both palliative and corrective surgery, the number of children with congenital heart disease surviving to adulthood has increased dramatically . Tetralogy of Fallot (TOF) is one of the conotruncal family of heart lesions in which the primary defect is an anterior deviation of the infundibular septum (the muscular septum that separates the aortic and pulmonary outflows). **Objective:** To revise patients with tetralogy of Fallot (TOF) underwent palliative or total corrective surgical repair in Madinah, Saudi Arabia. **Methods:** retrospective study was approved from the institutional review board of Madinah cardiac center and abandoned the need for patient consent. Patient Demographic data and procedure details were retrieved from the hospital information system (HIS). From 2014 till end of 2017, 72 patients had the diagnosis of TOF (ICD 10 code, Q21.3). Twelve patients were excluded from them. Thus, 60 patients were left as the study cohort. Fifty four patients had total repair from the start (Group I), 3 patients had initial palliative procedure (group II) and 3 patients had both initial palliative procedure then later total repair. All patients from 1 day to less than 14 years are included. All data were analyzed using GraphPad prism version 5.00 for windows. **Results:** 61.67% of our patients were males, and 38.33% were females with the ratio of 1.6 (Male: Female). Six (10%) cases were subjected to a palliative correction surgery (group I) and 57 (95%) cases were subjected to total repair surgery (group II). 11 (18.3%) cases had post-operative complications, 2 (18.2%) cases from group I and 9 (81.8%) cases from group II. Regarding to the type of surgery there was no statistically significant difference between gender and pre and post-operation stay. Also no significance with length of stay, re-intervention, mortality and complications. While there was a significant correlation between age, weight, RPA and LPA. **Conclusion:** In our cohort of TOF patients the incidence of the disease was higher among males than females. The continuous follow up was highly recommended for TOF patients. The outcomes of surgical treatment including palliative, total and intervention correction surgeries was a complete recovery of 28.33% of studied patients, and the remaining (71.67%) had post-surgical complications.

Keywords: Tetralogy of Fallot, Palliative, surgical correction, complication, congenital heart defect

INTRODUCTION

Tetralogy of Fallot (TOF) is a cyanotic congenital cardiac defect that was first described by Stenson in 1672 and later named for Fallot, who in 1888 described it as a single pathological process responsible for pulmonary outflow tract obstruction, ventricular septal defect (VSD), revoking aortic root, and right ventricular hypertrophy [1-3].

Tetralogy of Fallot occurs in 3 of every 10,000 live births. It is the most frequent cause of cyanotic cardiac disease in patients beyond the neonatal age and accounts for up to one-tenth of all congenital cardiac lesions [4]. The etiology is multifactorial, but reported associations include untreated maternal diabetes, phenylketonuria, and intake of retinoic acid. Associated chromosomal anomalies can consist of trisomies 21, 18, and 13, but up-to-date experience points to the much more frequent association of microdeletions of chromosome 22. The risk of recurrence in families is 3% [5]. Tetralogy of Fallot results in low oxygenation of blood due to the mixing of oxygenated and deoxygenated blood in the left ventricle, through the ventricular septal defect (VSD), and preferential flow of the mixed blood from both ventricles through the aorta because of the barrier to flow through the pulmonary valve. This is known as a right-to-left shunt. The primary symptom is known to be low blood oxygen saturation with or without cyanosis from birth or developing in the first year of life. If the baby is not cyanotic, then it is sometimes pointed to as a "pink tet" [6].

Congenital heart defects are now diagnosed with echocardiography, which is quick, involves no radiation, very specific, and can be done prenatally.

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Before more sophisticated techniques became available, the chest x-ray was the definitive method of diagnosis. The abnormal "Coeur-en-sabot" (boot-like) appearance of a heart with tetralogy of Fallot is classically visible via chest x-ray, although most infants with tetralogy may not show this finding [7].

Approximately 90% of untreated TOF patients succumb by the age of 10 years [8]. Over the years many surgical approaches were performed until the current primary repair was generated. Shunts are nowadays only done as a palliative procedure in inoperable cases or to bridge patients until the repair can be carried out, typically in the setting of pulmonary arterial hypoplasia [9].

Shunt operations included [8] shunts that include designed to reduce cyanosis, Pott shunt, Waterston shunt, Blalock-Taussig shunt and Primary repair .

This literature investigated the outcome of tetralogy of Fallot repair and surgical implications in Madinah region, Saudi Arabia, searches were done by reviewing journals and articles found in the internet databases like PubMed, CINAHL, and the Medscape Library. Several articles that were not accessible by full text from the databases were obtained using Google Scholar. Several studies have been conducted on the outcome of tetralogy of Fallot repair and surgical implications worldwide.

A study conducted by Jost *et al*. [9,10] reported that complete repair of TOF was feasible in patients 40 years or older but was associated with an increased operative risk. Surgical survivors have marked improvement in functional class, however, survival rates remain lower than expected. Reduced long-term survival and need for reoperation emphasize the importance of long-term, informed follow-up.

Another study conducted on Saudi Arabia by Ismail *et al*.[11] reported that Eighty-three patients met the study criteria. There were 64 cases (77%) in group I, and 19 cases (23%) in group II. All children tolerated surgical repair and did well. We observed no statistically significant difference in the postoperative ICU care, complications rates, and morbidity among all groups. There was no surgical mortality in all groups. In this study, we aimed to revise patients with tetralogy of Fallot (TOF) underwent palliative or total corrective surgical repair in Madinah, Saudi Arabia.

METHODS

The protocol of this retrospective study was approved from the institutional review board of Madinah cardiac center and abandoned the need for patient consent.

Data collection

Patient demographic data and procedure details were retrieved from the hospital information system (HIS). This database contains patients demographic data, dates of admission, procedures and discharge, diagnoses according to international classifications of disease, 10th revision (ICD 10) codes, imaging studies and laboratory data. Patient data queried included the following: date of birth, sex, date of admission, date of discharge, date of procedures and length of stay in intensive care. Individual patients records was then revised for further details including history and physical examination, other diagnoses, other anomalies, surgical notes, catheterization notes and echocardiography notes. Follow up data were revised also in outpatient clinics section of the patient records. Complications related to procedures were also revised during patients admission or during follow up period.

Inclusion and exclusion criteria

The inclusion criteria were all patients from 1 day to less than 14 years with a diagnosis of TOF (ICD 10 code, Q21.3) and who underwent surgical repair at our institution. Exclusion criteria were patients older than 14 years, patients had complete repair at other institution and patients with co-existing pulmonary valve atresia (ICD 10 code, Q22.0).

Study population

From 2014 till end of 2017, 72 patients had the diagnosis of TOF (ICD 10 code, Q21.3). Twelve patients were excluded from them: 4 patients have an additional pulmonary valve atresia (ICD 10 code, Q22.0) ,5 patients are adult patients older than 19 years and 3 patients had primary repair in other hospitals and had additional surgery for conduit stenosis or pulmonary arteries stenosis at our center (figure 1). Thus, 60 patients were left as the study cohort. Fifty four patients had total repair from the start (group I), 3 patients had initial palliative procedure (group II) and 3 patients had both initial palliative procedure then later total repair (were added to both groups). Group I was subdivided into three groups, group A had a Systemic to PA shunt, group B patients had a RVOT stent and group C had a pulmonary valvuloplasty. Group II was subdivided into two groups, group A had a total repair with transanular patch and group B had a total repair without transanular patch.

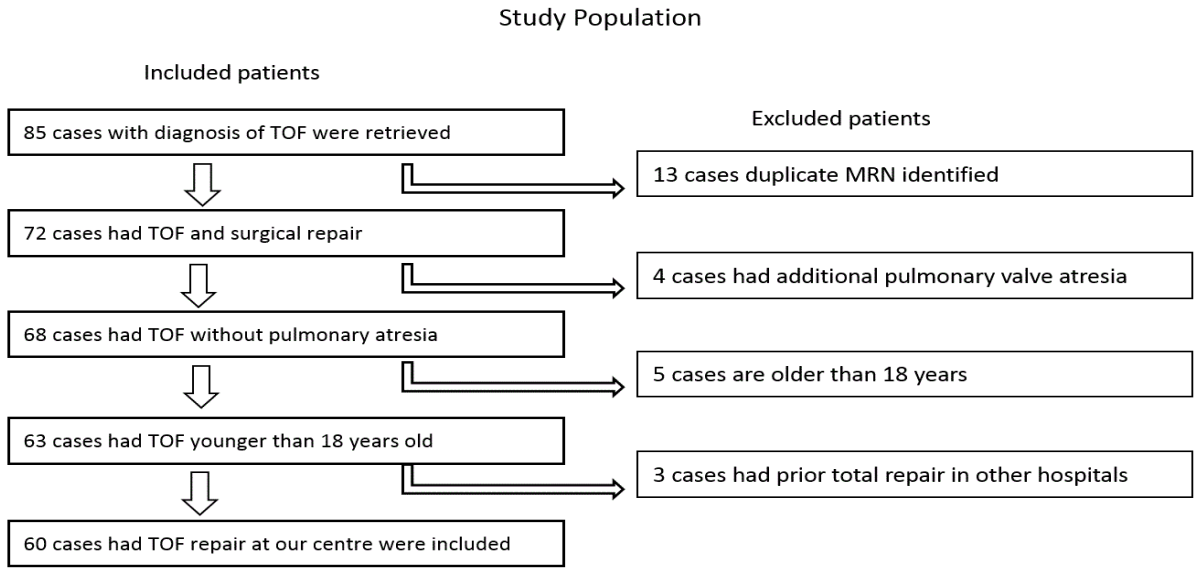

Figure 1: distribution of study population

Statistical analysis

All data were analyzed using GraphPad prism version 5.00 for windows. Graphpad software, San Diego Calfornia USA). Descriptive statistics were expressed as mean and standard deviation for continuous variables and percentages and frequencies for categorical variables. Unpaired t test with Welch correction was used to compare continuous variables and Chi-square test for categorical variables. P value less than 0.05 indicated statistical significance.

RESULTS

Sixty patients fulfilled the study criteria. 39 (65%) were males and 21(35%) were females with the ratio of 1.86 (Male: Female). Six (10%) cases were subjected to a palliative correction surgery (group I) and 57 (95%) cases were subjected to total repair surgery (group II). Group I was subdivided into three groups, group A had a Systemic to PA shunt and included 3 patients (50%), group B patients had a RVOT stent and included 2 patients (33.3%) and group C had a pulmonary valvuloplasty and included 1 patient (16.7%). Group II was subdivided into two groups, group A had a total repair with transanular patch and included 41 patients (71.9%) and group B had a total repair without transanular patch and included 16 patients (28.1%). The mean±SD of age in months, weight in kilograms, and follow up periods in months were (6 ± 3.6), (5 ± 0.28) and (64 ± 53.34) respectively (Table 1).

Three of sixty patients (5%) were subjected to both palliative and total correction surgeries respectively. The distribution of patients regarding to the type of surgery and gender was illustrated in Figure 2.

Table (1) Population characteristics:

tal Number	
Gender (Male: Female)	39:21
Age at operation (mean ±SD) (Months)	14.1±10.8
Weight (mean ±SD) (Kg)	10.2±7.7
Follow up period (months)	24.7±13.3
Type of Palliative surgery	6
Systemic to PA shunt	3 (50%)
RVOT stent	2(33.3%)
pulmonary valvuloplasty	1(16.7%)
Type of Total Repair	57
With transanular patch	41 (71.9%)
Without transanular patch	16 (28.1%)

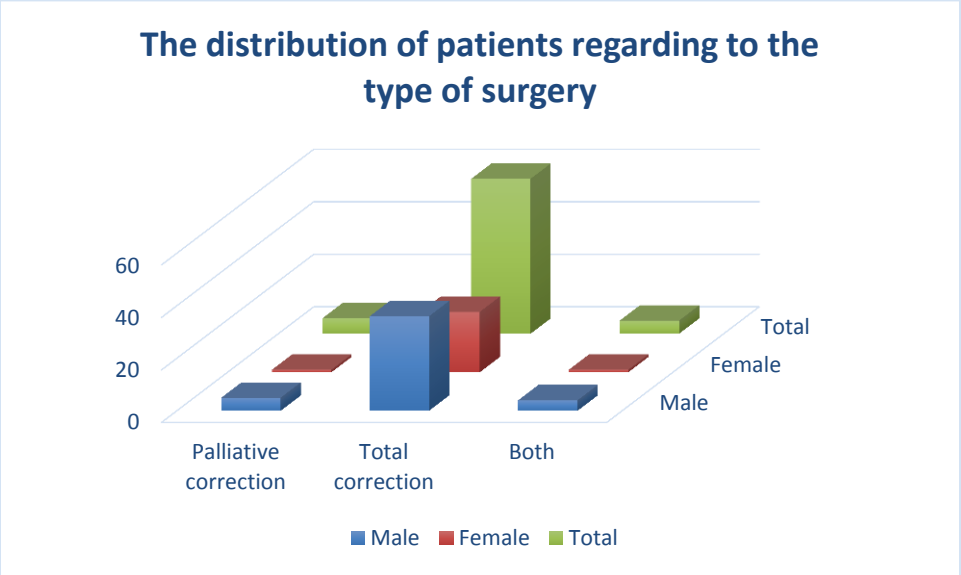

Figure 2: The distribution of patients regarding to the type of surgery

Forty of sixty patients (23.3%) were subjected to post-surgical interventions. Ten of them (71.4%) were males, and four (28.6%) were females with the ratio of 2.5 (Male: Female) (Table 2) (Figure 3).

Table 2: The frequency of post-surgical interventions among our patients:

Gender	Intervention	Non-intervention	Total
Male	10	27	37
Female	4	19	23
Total	14	46	60

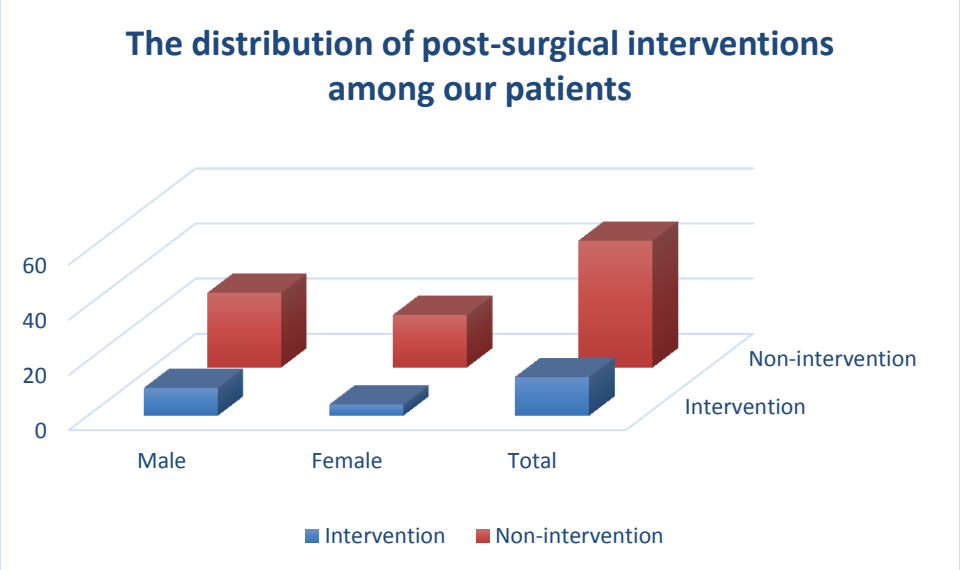

Figure 3: The distribution of post-surgical interventions among our patients regarding to gender.

Our results observed 3 mortality cases, one mortality case in patient from group (A) and two cases from group B. 11 (18.3%) cases had post-operative complications, 2 (18.2%) cases from group I and 9 (81.8%) cases from group II. These complications were classified as, 6 (10%) Transient Arrythmia, 2 (3.3%) complete heart block, 2 (3.3%) Rebleeding, 5 (8.3%) Pleural effusion, 2 (3.3%) Pneumothorax, 3 (5%) Acute renal failure, 1 (1.7%) Significant residual RVOTO, 2 (3.3%) Significant TR, 5 (8.3%) Re-intervention, 5 (8.3%) Pulmonary branch stenosis and 3 (5%) death (Table 4). These results indicated that one case may have more than one complication.

When we first compared groups I and II. Regarding to the type of surgery there was no statistically significant difference between gender, pre and post-operation stay, length of stay, re-intervention, mortality and complications. While there was a significant correlation between age, weight, RPA and LPA (P= 0.003, 0.009, 0.0001 and 0.0002 respectively) regarding to the type of surgery (Table 3). The older children with larger weight were subjected to complete repair surgery.

Table 3: comparison between palliative and complete repair surgeries regarding to the demographic features and post and pre-operation data:

Parameter	Palliative Procedures (n=6)	Complete Repair(n=57)	P value
Age in months (mean± SD)	6.8±3.6	14.8±11.1	0.003
Male/Female	4/2	35/19	NS
Weight	6±2.3	10.8±7.9	0.009
Follow up Periods (months)	(64 ± 53.34)	(36 ± 64.90)	NS
Pre-Op stay	0.6±0.5	1.1±0.4	NS
Post-Op stay	11±12.8	8.5±8.3	NS
Length of stay	11.6±13.1	9.6±8.3	NS
RPA	2.9±0.81	3.8±0.37	0.0001
LPA	3.06±0.22	3.7±0.45	0.0002
Re-intervention(n)	1	5	NS
Deaths(n)	1	2	NS
Complications(n)	2	9	NS

Table 4: Types of complications and its percentage:

	Number (%)
Transient Arrythmia	6(10)
Complete heart block	2(3.3)
Rebleeding	2(3.3)
Pleural effusion	5(8.3)
Pneumothorax	2(3.3)
Acute renal failure	3(5)
Significant residual RVOTO	1(1.7)
Significant TR	2(3.3)
Re-intervention	5(8.3)
Pulmonary branch stenosis	5(8.3)
Death	3(5)

Regarding to the cases abnormalities, our results reported that 42 (70%) cases had no abnormalities while 18 (30%) cases were associated with some abnormalities which distributed as, 3 (5%) PDA, 2 (3.3%) PFO, 6 (10%) ASD, 8 (13.3%) Right aortic arch, 6 (10%) Tricuspid regurge, 6 (10%) Left SVC, 6 (10%) Other cardiac problems, 3 (5%) Down`s syndrome, 5 (8.3%) Digeorge syndrome, 5 (8.3%) Neurological problems and 2 (3.3%) AVSD (Table 5).

Table 5: Types of abnormalities associated to TOF in the population

No associated anomalies	**42**
PDA	3
PFO	2
ASD	6
Right aortic arch	8
Tricuspid regurge	6
Left SVC	6
Other cardiac problems	6
Down`s syndrome	3
Digeorge syndrome	5
Neurological problems	5
AVSD	2

Group II (complete repair surgey) was subdivided into two groups, group A had a total repair with transanular patch and included 41 patients (71.9%) and group B had a total repair without transanular patch and included 16 patients (28.1%).Our results reported no significant correlations between the two sub groups regarding to the demographic features and post and pre-operation data (Table 6).

Table 6: comparison two sub groups of complete repair surgeries regarding to the demographic features and post and pre-operation data:

Parameter	With transannular Patch (41)	Without transannular patch (16)	P value
Age (mean± SD)	12.2±8.3	17.8±12.1	NS
Male/Female	25/13	10/6	NS
Weight	10.6±7.7	11.1±8.3	NS
Pre-Op stay	1.1±0.4	1.1±0.3	NS
Post-Op stay	8.6±7.9	8.4±8.4	NS
Length of stay	9.5±7.8	9.7±8.5	NS
RPA	3.7±0.41	3.9±0.35	NS
LPA	3.6±0.38	3.8±0.34	NS
Re-intervention	3	2	NS
Deaths	1	1	NS
Complications	9		NS
Previous Palliative repair	5	1	

Forty-three of sixty patients (71.67%) had post-surgical complications. Thirty one of them (72.09%) were males, and twelve (27.9%) were females with the ratio of 2.58 (Male: Female) (Table 4). These complications included VSD residual, free pulmonary regurgitation, arrhythmia, conduit stenosis / RVOTO, pulmonary stenosis, and death.

There was no significant correlation between the occurrences of post-surgical complications regarding age and weight where the P-values were (0.15 and 0.59 respectively) (Table 5).

The occurrence of postoperative complications was significantly related to gender where it was higher among males (P-value= 0.018).

DISCUSSION

One-stage total correction is apparently the best operation for tetralogy of Fallot if it is feasible [13]. However, in those patients in whom a preliminary palliative operation is unavoidable, the question which should concern us nowadays is not which procedure offers the best immediate relief of

symptoms but which one gives the best preparation for subsequent total correction [13].

Our study found that the incidence of the TOF was higher among males than females where the number of males was 1.6 times higher than females. These results agreed with **Rammohan *et al*.**[14] results that found that the number of males who had TOF in his study was 2.22 times higher than females. While Sarikouch et al., 2011 reported that male patients who had TOF had higher indexed volumes and mass of the RV and LV than female patients. This was awaited as sex differences of such parameters were previously noted in healthy populations [15-18]. On the other hand, female patients who had TOF had raised EFs in both ventricles over male patients, whereas in healthy patients, no significant sex differences were reported [15, 16,18].

The following up along with clinical status helping in the periodical evaluation of most abnormalities with imaging modalities to determine the best timing for medical or surgical treatment [19]. In our study the palliative surgery required the longer period of following up than total correction surgery where it was (64 ± 53.34) and (36 ± 64.90) months respectively. These results agreed with the study conducted with Sanchez et al., 1985 [20] which stated that the minimum follow-up was six months and the longest, eight years (mean duration, 4.25 years).

Now, most babies who have tetralogy of Fallot have their defects fully repaired in infancy. However, some babies are too weak or too small to have the full repair. They must have temporary surgery first. This operation improved oxygen levels in the blood and was known as palliative surgery. It also gives the baby time to grow and get strong enough for the full repair [21]. In our study, 10% of patients were subjected to previous palliative correction surgeries. While in ***Rammohan et al.*** [14] study twenty-two patients (22%) had prior palliative shunts.

Complications of different severity occur almost invariably after TOF repair leading to considerable morbidity and even mortality [22]. In our study 11 (18.3%) cases had post-operative complications, 2 (18.2%) cases from group I and 9 (81.8%) cases from group II. These complications included transient arrythmia, complete heart block, rebleeding, pleural effusion, pneumothorax, acute renal failure, significant residual RVOTO, significant TR, Re-intervention, pulmonary branch stenosis and death. ***Ho et al.*** [22] also reported that many challenges persist resulting from complications like severe pulmonary regurgitation, right ventricular dilatation, RVOT obstruction, VSD patch leakage, arrhythmias and sudden cardiac death. It is crucial that adult TOF patients should have regular follow-up to observe the development and subsequent management of these complications [22].

CONCLUSION

In our cohort of TOF patients, the incidence of the disease was higher among males than females. The continuous follow up was highly recommended for TOF patients. The outcomes of surgical treatment including palliative, total and intervention correction surgeries was a complete recovery of 28.33% of studied patients, and the remaining (71.67%) had post-surgical complications. These complications included VSD residual, free pulmonary regurgitation, arrhythmia, conduit stenosis / RVOTO, pulmonary stenosis, and death.

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