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Original Article

Surgery Section

Analysis of Surgical Outcomes and Clinical Improvements Following Surgery in Tetralogy of Fallot: A Retrospective Cohort Study

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ABSTRACT

Introduction: Tetralogy of Fallot (ToF), is the most common type of cyanotic Congenital Heart Disease (CHD). Even after anatomic correction and physiological correction complications such as pulmonary regurgitation leading to Right Ventricular (RV) dysfunction, recurrent obstruction of the RV outfl ow tract, arrhythmias and sudden death are found in late survivors.

Aim: To analyse the clinical presentation, surgical outcomes, and clinical improvements after surgical repair of ToF.

Materials and Methods: The present single-centre, retrospective cohort study was carried out, from 1st January 2005 to 31st December 2015. Case records of consecutive patients aged 18 years and above who underwent Intra cardiac repair for ToF in the Institute of Cardiovascular Diseases, The Madras Medical Mission, Chennai, Tamil Nadu, India, institute were analysed. Patient baseline characteristics, symptoms, New York Heart Association Class, and associated complications were studied. Preoperative Electrocardiogram (ECG) and Echocardiogrphy (ECHO) findings were recorded. Data was analysed by using coGuide software.

Results: A total of 41 subjects (mean age 27.3±10.2 years; 56.1% male) were analysed. Cyanosis (85.4%), dyspnoea (75.6%), and clubbing (63.4%) were the most common preoperative symptoms. Preoperative New York Heart Association (NYHA) class II/III was common, with significant improvement noted at follow-up, where 43.9% of patients were asymptomatic ($p<0.05$). Oxygen saturation increased from 83.8% to 98.5% ($p<0.001$), and RVOT gradient decreased significantly ($p<0.001$). ECG differences were observed between preoperative, postoperative, and follow-up stages ($p<0.05$). Significant differences were also found between procedures like infundibular resection (alone), pulmonary valve commissurotomy (alone), trans annular patch and PR status ($p<0.05$).

Conclusion: The results of the present study showed that long-term survival after successful surgical correction of ToF was good.

Keywords: Congenital heart defects, Heart valve diseases, Treatment outcome

INTRODUCTION

The ToF, the most common type of cyanotic CHD, has an incidence of 0.34 per 1000 live births [1]. The classic tetrad was first described in 1673 by bishop and anatomist Nicolas Steno, but the anatomy was more extensively described by the French physician Étienne-Louis Fallot in 1888 [2,3]. ToF occurs in three of every 10,000 live births [4]. It is the most common cause of cyanotic cardiac disease in patients beyond the neonatal age and accounts for up to one-tenth of all congenital cardiac lesions [5]. The aetiology is multifactorial, but reported associations include untreated maternal diabetes, phenylketonuria, and intake of retinoic acid.

Associated chromosomal anomalies can include trisomies 21, 18, and 13, but recent experience points to the much more frequent association of microdeletions of chromosome 22 [4]. The risk of recurrence in families is 3%. Patients nowadays usually present as neonates, with cyanosis of varying intensity based on the degree of obstruction to the flow of blood to the lungs [4]. Surgical repair for ToF was first reported in 1954 for a cohort of 106 patients, with a 30-year survival of 77% [6]. Long-term outcome data for patients with repaired ToF have been derived from single-centre series, typically from tertiary referral centres [7-9], with results largely influenced by the centre's surgical experience [10] or from non-US cohorts leveraging national health registries [11-13].

Although anatomic correction and physiological correction have been achieved, complications such as pulmonary regurgitation leading to Right Ventricular (RV) dysfunction, recurrent obstruction of the RV outflow tract, arrhythmias, sudden death, aortic dilation and regurgitation are found in late survivors. Long-term survival is reported to be excellent but still lower than that of the normal population [14]. It remains uncertain whether these results last for a lifetime and whether subgroups of patients may achieve normal life expectancy [15-18]. Hence, in the present study the investigators sought to analyse the clinical presentation, surgical outcomes, and clinical improvements after surgical repair of ToF.

MATERIALS AND METHODS

The present single-centre, retrospective cohort study was conducted at the Institute of Cardiovascular Diseases, The Madras Medical Mission, Chennai, Tamil Nadu, India, from 1st January 2005 to 31st December 2015. The data was subsequently analysed between January and June 2024. Ethical approval was obtained from the Institutional Review Board (Ref: IHEC ECR/140/Inst/TN/2013). The study examined case records of consecutive patients aged 18 years and above who underwent intra cardiac repair for ToF at the Department of Cardiothoracic Surgery.

Inclusion and Exclusion criteria: Males or females aged 18 years and above and those with a verified diagnosis of ToF and who had undergone total intracardiac repair were included in the study. Patients with other complex conditions (Previous palliative systemic to pulmonary artery shunts, ToF with Pulmonary atresia, ToF with absent pulmonary valve syndrome, ToF with AV canal defects) were excluded.

Sample size: The sample size was determined based on the study "Long-term results of correction of ToF in Adulthood" authored by Atik FA et al., [19]:

- The confidence level was estimated at 95% with a z value of 1.96
- The confidence interval or margin of error was estimated at ±13
- Assuming p% =79.4 and q%=20.6

  $n = p\% \times q\% \times (z/e\%)^2$

  $n = 95.2 \times 4.8 \times (1.96/6)^2$

  $n = 37.18$

Therefore, 37 was the minimum sample size required for the study. The sample taken in this study was 41.

Procedure

The case records of patients who were operated for ToF during the study period were used to collect the data. Patient baseline characteristics, symptoms, NYHA Class, and associated complications were studied. Preoperative ECG and ECHO findings were recorded. Details about operative surgery were obtained from operative notes. Details about hospital stay, and any complications encountered were collected from the hospital case records. Morbidity parameters evaluated were invasive ventilation hours, re-exploration, Intensive Care Unit (ICU) stay, inotrope requirements, hospital stay, and major organ system complications. Similarly, follow-up details were also obtained. The results of the last available ECG, Transthoracic ECHO were entered. ECHO was used to assess the valvular and ventricular function of the heart.

Echocardiographic parameters included: (1) Severity of valvular regurgitation based on Doppler echocardiographic assessment, classified as none, mild, moderate, or severe as per the guidelines laid out by the British Society of Echocardiography which was followed in the hospital; (2) Systolic function of the left and right ventricles, classified as none, mild, moderate, or severe dysfunction [20].

STATISTICAL ANALYSIS

Mortality and morbidity, NYHA class was considered as an explanatory variable. demographics and clinical symptoms etc., were considered as study relevant variables. Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency, and proportion for categorical variables. The change in the quantitative parameters, before and after the intervention was assessed by paired t-test (In case of two time periods). For normally distributed quantitative parameters the mean values were compared between study groups using independent sample t-test (2 groups). Categorical outcomes were compared between study groups using Fisher's-exact test. The p-value <0.05 was considered statistically significant. Data was analysed by using coGuide software [21].

RESULTS

A cohort of 41 subjects (56.10% male) with a mean age of 27.27±10.20 years (range:18-54) was included in the final analysis. Preoperatively, 85.37% presented with cyanosis, while low cardiac output (7.32%), CNS (Seizure) and respiratory complications (lung consolidation) (2.44%) were less common [Table/Fig-1].

Most patients were classified as NYHA class II or III preoperatively, improving to predominantly class II (68.29%) at follow-up. Preoperative ECG showed sinus rhythm in 90.24% of participants, while incomplete Right Bundle Branch Block (RBBB) was the predominant finding (39.02%) at follow-up. Postoperative haemodynamic parameters revealed mean aortic systolic pressure of 100.39±13.22 mmHg, RV systolic pressure of 41.05±11.45 mmHg, and pulmonary artery systolic pressure of 27.71±8.54 mmHg. At follow-up, mild aortic and tricuspid regurgitation were observed in 7.32% and 17.07% of patients, respectively [Table/Fig-2].

Aortopulmonary collaterals were present in 9.76% of patients, with one patient (2.44%) requiring coiling. The mean cardiopulmonary bypass time was 156.32±40.82 minutes, with a mean aortic cross-clamp time

Parameters	Summary
Age (years)	27.27±10.20 (Range 18 to 54)
Gender	
Male	23 (56.10%)
Female	18 (43.90%)
Preoperative Height (cm)	159.39±8.47 (Range 147 to 182)
Preoperative Weight (kg)	44.88±10.28 (Range 28.2 to 74)
Preoperative Body Surface Area (msg)	1.40±0.18 (Range 1.07 to 1.84)
Preoperative Clinical Manifestations	
Dyspnoea	31 (75.61%)
Cyanosis	35 (85.37%)
Cyanotic Spells	10 (24.39%)
Clubbing	26 (63.41%)
Syncope	0 (0.00%)
Stroke	1 (2.44%)
Haemoptysis	1 (2.44%)
Endocarditis	0 (0.00%)
Brain Abscess	3 (7.32%)
Other Illness	0 (0.00%)
Complications	
Low Cardiac output	3 (7.32%)
CNS	1 (2.44%)
Renal	0 (0.00%)
Gastrointestinal	0 (0.00%)
Respiratory	1 (2.44%)

[Table/Fig-1]: Descriptive analysis of demographic parameters (N=41).

Parameters	Preoperative	Postoperative	Follow-up
NYHA Functional Classification			
Class I	0 (0.00%)	-	13 (31.71%)
Class II	18 (43.90%)		28 (68.29%)
Class III	18 (43.90%)		0 (0.00%)
Class IV	5 (12.20%)		0 (0.00%)
Peripheral Capillary Oxygen Saturation (%)	83.78±5.88 (Range 72 to 96)	-	98.49±1.69 (Range 94 to 100)
ECG Findings			
Sinus	37 (90.24%)	30 (73.17%)	24 (58.54%)
Incomplete RBBB	4 (9.76%)	10 (24.39%)	16 (39.02%)
Complete Heart Block		1 (2.44%)	1 (2.44%)
RVOT Gradient (mm Hg)	86.93±18.05 (Range 50 to 124)	13.76±8.41 (Range 0 to 34)	14.07±7.33 (Range 5 to 35)
Residual VSD			
Yes	-	5 (12.20%)	5 (12.20%)
No		36 (87.80%)	36 (87.80%)
VSD type			
Semimembranosus	2 (4.88%)	-	-
Subaortic	37 (90.24%)		
Subaortic with Inlet Extension	1 (2.44%)		
Subpulmonic	1 (2.44%)		
RV dysfunction			
Mild	3 (7.32%)	-	5 (12.20%)
Nil	38 (92.68%)		36 (87.80%)
LV dysfunction			
Mild	0 (0.00%)	-	0 (0.00%)
Nil	41 (100.00%)		41 (100.00%)
Pulmonary valve			
Bicuspid	12 (29.27%)	-	-
Tricuspid	29 (70.73%)		

Associated anomalies			
Right Aortic arch	4 (9.76%)	-	-
Muscular VSD	1 (2.44%)		
Severe TR	1 (2.44%)		
LPA Stenosis Origin	1 (2.44%)		
OS ASD	2 (4.88%)		
Moderate AR	1 (2.44%)		
Coronary Crossing RVOT	3 (7.32%)		
Pulmonary regurgitation			
Mild	-	4 (9.76%)	4 (9.76%)
Severe		27 (65.85%)	27 (65.85%)
Nil		10 (24.39%)	10 (24.39%)
Repair pressures (mm Hg)			
Aorta - Systolic	-	100.39±13.22 (Range 80 to 138)	-
Right Ventricular (RV) - Systolic	-	41.05±11.45 (Range 18 to 67)	-
Pulmonary Artery -Systolic	-	27.71±8.54 (Range 15 to 58)	-
Last Follow-up (years)	-	-	2.63±1.44 (Range 1 to 5)
Aortic regurgitation			
Mild	-	-	3 (7.32%)
Nil			38 (92.68%)
Tricuspid regurgitation			
Mild	-	-	7 (17.07%)
Moderate			1 (2.44%)
Nil			33 (80.49%)

[Table/Fig-2]: Descriptive analysis of post, and follow-up parameters.
rvot, VSD: Ventricular Septal Defect; ASD: Atrial septal defect

of 95.63±30.11 minutes. The mean ratio of RV systolic pressure to aortic systolic pressure was 0.42±0.13. All patients underwent VSD closure via transatrial approach, with 95.12% receiving infundibular resection and 60.98% requiring a transannular patch. Most patients had ICU stays ≤3 days (65.85%) and hospital stays ≤8 days (73.17%). No reoperations or mortality were reported [Table/Fig-3].

Peripheral capillary oxygen saturation improved significantly from preoperative (83.78±5.88%) to follow-up (98.49±1.69%) (p<0.001). Significant reductions in (Right Ventricular Outflow Tract) RVOT gradient were observed between preoperative and postoperative measurements, and between postoperative and follow-up measurements (p<0.001 for both) [Table/Fig-4]. Statistically significant differences (p<0.05) were found in NYHA classification between preoperative and follow-up periods, between all ECG comparison timepoints, and between different surgical procedures and PR status [Table/Fig-5].

DISCUSSION

This retrospective study analysed the clinical presentations, surgical outcomes, and follow-up improvements using case records of consecutive patients aged 18 years and above who underwent intra-cardiac repair for ToF. It was observed that the majority of participants presented with cyanosis as the predominant preoperative symptom, followed by dyspnea. These findings align with previous studies that also reported cyanosis as a common symptom in ToF cases [22]. The high prevalence of cyanosis reflects the significant obstructive physiology typically seen in unrepaired ToF, which improves substantially after surgical correction.

All patients underwent intracardiac repair, with surgical techniques tailored to individual needs. Postoperatively, the RVOT gradient showed a significant reduction from preoperative levels (p<0.001), aligning with improvements reported by Upadhyay V et al., (preoperative: 85.93±5.73 mmHg to postoperative: 27.7±3.1 mmHg) [23] and Kaushal SK et al., (preoperative RVOT gradient: 54±15.4

Parameters	Summary
AP collaterals	
Yes	4 (9.76%)
No	37 (90.24%)
Coiling	
Yes	1 (2.44%)
No	40 (97.56%)
CPB Time (min)	156.32±40.82 (Range 105 to 296)
AXC Time (min)	95.63±30.11 (Range 63 to 190)
The ratio of Right Ventricular (RV) systolic pressure to aortic systolic pressure	0.42±0.13 (Range 0.18 to 0.76)
Pacemaker use	
Yes	1 (2.44%)
No	40 (97.56%)
Re exploration	
Yes	2 (4.88%)
No	39 (95.12%)
Invasive ventilation hours	15.17±8.01 (Range 6 to 40)
Inotrope requirement	
1 day	6 (14.63%)
2 days	27 (65.85%)
3 days	8 (19.51%)
ICU stay (days)	
≤3 days	27 (65.85%)
4-5 days	13 (31.71%)
>5 days	1 (2.44%)
Hospital stay	
≤8 days	30 (73.17%)
9-12 days	10 (24.39%)
>12 days	1 (2.44%)
Re-operation	
Yes	0 (0.00%)
No	41 (100.00%)
Mortality	
Yes	0 (0.00%)
No	41 (100.00%)
Cardioplegia	
Hypo BCP	17 (41.46%)
Hypo crystalloid BCP	4 (9.76%)
Delnido	20 (48.78%)
Surgery	
VSD closure trans atrial approach	41 (100.00%)
VSD closure transpulmonary approach	5 (12.20%)
VSD closure trans ventricular approach	4 (9.76%)
Infundibular resection with other procedures	39 (95.12%)
Infundibular resection alone	2 (4.88%)
Pulmonary valve commissurotomy	3 (7.32%)
RVOT patch reconstruction	2 (4.88%)
Transannular patch	25 (60.98%)
Transannular patch with monocusp	8 (19.51%)
Associated procedure	8 (19.51%)

[Table/Fig-3]: Descriptive analysis of operative parameters.

mmHg in Group 2 vs 21.22±8.8 mmHg in Group 1, p=0.0001) [24], demonstrating the efficacy of modern surgical techniques in relieving RV outflow obstruction and improving cardiac output. Interestingly, no mortality cases were observed in our cohort. Two large cohort studies of patients with repaired ToF have shown survival rates of approximately 90% during the first two decades of life [24,25].

Parameters	Preoperative	Postoperative	Follow-up
Peripheral capillary oxygen saturation	83.78±5.88	-	98.49±1.69
Mean difference	14.71		
p-value	<0.001		
RVOT gradient	86.93±18.05	13.76±8.41	14.07±7.33
Mean difference	73.17	72.85	0.32
p-value	<0.001	<0.001	0.783

[Table/Fig-4]: Comparison of preoperative parameters with follow-up parameters in the study population (paired t-test).

NYHA	NYHA Follow-up			p-value
	Mild symptoms	No symptoms		
Class I	13 (31.71%)	0 (0%)	-	<0.001*
Class II	28 (68.29%)	18 (43.9%)		
Class III	0 (0%)	18 (43.9%)		
Class IV	0 (0%)	5 (12.2%)		
ECG related Follow-up time periods				
Post ECG	**Preoperative ECG**			
	Incomplete RBBB (N=4)	**Sinus (N=37)**		
CHB	0 (0%)	1 (2.7%)	-	0.003*
RBBB	4 (100%)	6 (16.22%)		
Sinus	0 (0%)	30 (81.08%)		
ECG Follow-up				
CHB	0 (0%)	1 (2.7%)	-	0.024*
RBBB	4 (100%)	12 (32.43%)		
Sinus	0 (0%)	24 (64.86%)		
ECG Follow-up	**Post ECG**			
	CHB (N=1)	**RBBB (N=10)**	**Sinus (N=30)**	
CHB	1 (100%)	0 (0%)	0 (0%)	<0.001*
RBBB	0 (0%)	10 (100%)	6 (20%)	
Sinus	0 (0%)	0 (0%)	24 (80%)	
Surgical correction	**PR Present (N=31)**	**PR Absent (N=10)**		
VSD closure trans atrial approach	31 (100.00%)	10 (100.00%)	-	>0.9999*
VSD closure transpulmonary approach	3 (9.68%)	2 (20.00%)	-	0.5801*
VSD closure trans ventricular approach	4 (12.90%)	0 (0.00%)	-	0.5561*
Infundibular resection with other procedures	31 (100.00%)	8 (80.00%)	-	0.0449*
Infundibular resection alone	0 (0.00%)	2 (20.00%)	-	0.0449*
Pulmonary valve commissurotomy (Alone)	0 (0.00%)	3 (30.00%)	-	0.0113*
RVOT patch reconstruction (Alone)	0 (0.00%)	1 (10.00%)	-	0.2439*
Transannular patch	22 (70.97%)	3 (30.00%)	-	0.0301*
Transannular patch with monocusp	5 (16.13%)	3 (30.00%)	-	0.1435*
Associated procedure	4 (12.90%)	4 (40.00%)	-	0.0821*
Parameters	**Pulmonary regurgitation (Mean± SD)**			
	Present (N=31)	**Absent (N=10)**		
Invasive ventilation (Hours)	15.68±8.56	13.6±6.06	-	0.483†
ICU stay	3.42±0.92	3.3±0.82	-	0.718†
Inotrope requirement (Days)	2.06±0.57	2±0.67	-	0.768†
Hospital stay	8.71±1.35	8.1±0.32	-	0.167†

[Table/Fig-5]: Comparison of NYHA improvement parameters.
*=p-value Fishers-Exact Test; †=Independent Sample t-test p-value

During the follow-up period, averaging 2.63 years, patients showed marked improvements in functional status. None of the participants reported NYHA class II or III symptoms, with the majority classified as NYHA class I or II. This improvement aligns with findings by Atik FA et al., and Sadiq A et al., who demonstrated similar functional recoveries in patients undergoing surgical repair for ToF [19,26]. The increase in peripheral capillary oxygen saturation from preoperatively to follow-up ($p<0.001$), as noted by Bronicki RA et al., indicates a significant enhancement in oxygenation, reflecting improved pulmonary blood flow and reduced right-to-left shunting [27].

Postoperative ECG findings revealed a reduction in sinus rhythm abnormalities, with significant differences observed between preoperative and follow-up results ($p<0.05$). Unlike the findings by Massin MM et al., [28] who associated prolonged QRS durations (≥180 ms) with ventricular dysfunction, The current study did not observe such complications. This suggests that early and precise surgical interventions can mitigate the risks of long-term arrhythmic complications. Overall, The present study supports the effectiveness of intra-cardiac repair in improving both functional outcomes and cardiovascular health, with favorable long-term results in patients with ToF.

Limitation(s)

The current study has fewer limitations. The current study was a retrospective study hence there were chances of selection bias. Cardiac catheterisation data were not used in our study since only a small number of patients underwent a catheterisation study. This is due to the improvement in cardiac echocardiogram which has reduced the role of invasive catheterisation studies. Quantitative echocardiography parameters are not analysed in our study, this is because only a small number of case records in our hospital had quantitative parameters. We recommend prospective studies to be conducted in the future with a multi-centric approach.

CONCLUSION(S)

The results of this study demonstrate that long-term survival following successful surgical correction of ToF is excellent, with significant improvements in clinical outcomes. Cyanosis, the most common presenting symptom, was greatly alleviated postsurgery. Most patients showed marked improvement in NYHA functional class, reflecting the positive impact of the surgical intervention. Furthermore, no cases of late RV dysfunction were observed, indicating the effectiveness and durability of the surgical repair. Although there was an increased incidence of tricuspid regurgitation, it did not affect the overall cardiac function.

REFERENCES

[1] Van Der Linde D, Konings EEM, Slager MA, Witsenburg M, Helbing WA, Takkenberg JJM, et al. Birth prevalence of congenital heart disease worldwide. J Am Coll Cardiol. 2011;58(21):2241-47.
[2] Fallot A. Contribution à l'anatomie pathologique de la maladie bleue (cyanose cardiaque),. Marseille: Impr. de Barlatier-Feissat; 1888. 105 p.
[3] Neill CA, Clark EB. Tetralogy of fallot. The first 300 years. Tex Heart Inst J. 1994;21(4):272-79.
[4] Bailliard F, Anderson RH. Tetralogy of fallot. Orphanet J Rare Dis. 2009;4(1):2.
[5] Ferencz C, Rubin JD, McCarter RJ, Brenner JI, Neill CA, Perry LW, et al. Congenital heart disease: Prevalence at livebirth. The Baltimore-Washington Infant Study. Am J Epidemiol. 1985;121(1):31-36.
[6] Lillehei CW, Varco RL, Cohen M, Warden HE, Gott VL, Dewall RA, et al. The first open heart corrections of tetralogy of fallot: A 26–31 year follow-up of 106 patients. Ann Surg. 1986;204(4):490.
[7] Horneffer PJ, Zahka KG, Rowe SA, Manolio TA, Gott VL, Reitz BA, et al. Long-term results of total repair of tetralogy of fallot in childhood. Ann Thorac Surg. 1990;50(2):179-85.

[8] Cobanoglu A, Schultz JM. Total correction of tetralogy of fallot in the first year of life: Late results. Ann Thorac Surg. 2002;74(1):133-38.
[9] Bacha EA, Scheule AM, Zurakowski D, Erickson LC, Hung J, Lang P, et al. Long-term results after early primary repair of tetralogy of Fallot. J Thorac Cardiovasc Surg. 2001;122(1):154-61.
[10] Knott-Craig CJ, Elkins RC, Lane MM, Holz J, McCue C, Ward KE. A 26-year experience with surgical management of tetralogy of fallot: Risk analysis for mortality or late reintervention. Ann Thorac Surg. 1998;66(2):506-10.
[11] Chiu SN, Wang JK, Chen HC, Lin MT, Wu ET, Chen CA, et al. Long-term survival and unnatural deaths of patients with repaired tetralogy of fallot in an Asian cohort. Circ Cardiovasc Qual Outcomes. 2012;5(1):120-25.
[12] Nollert G, Fischlein T, Bouterwek S, Böhmer C, Klinner W, Reichart B. Long-Term survival in patients with repair of tetralogy of fallot: 36-year follow-up of 490 survivors of the first year after surgical repair. J Am Coll Cardiol. 1997;30(5):1374-83.
[13] Hickey EJ, Veldtman G, Bradley TJ, Gengsakul A, Manlhiot C, Williams WG, et al. Late risk of outcomes for adults with repaired tetralogy of Fallot from an inception cohort spanning four decades. Eur J Cardiothorac Surg. 2009;35(1):156-64.
[14] 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(9):593-99.
[15] Roos-Hesselink J, Perlroth MG, McGhie J, Spitaels S. Atrial arrhythmias in adults after repair of tetralogy of Fallot. Correlations with clinical, exercise, and echocardiographic findings. Circulation. 1995;91(8):2214-19.
[16] Rosenthal A. Adults with tetralogy of fallot -- repaired, yes; cured, no. N Engl J Med. 1993;329(9):655-56.
[17] Apitz C, Webb GD, Redington AN. Tetralogy of Fallot. Lancet Lond Engl. 2009;374(9699):1462-71.
[18] Bouzas B, Kilner PJ, Gatzoulis MA. Pulmonary regurgitation: Not a benign lesion. Eur Heart J. 2005;26(5):433-39.
[19] Atik FA, Atik E, da Cunha CR, Caneo LF, Assad RS, Jatene MB, et al. Long-term results of correction of tetralogy of Fallot in adulthood. Eur J Cardiothorac Surg. 2004;25(2):250-55.
[20] Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, et al. Recommendations for chamber quantification: A report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. J Am Soc Echocardiogr Off Publ Am Soc Echocardiogr. 2005;18(12):1440-63.
[21] BDSS corp. coGuide. Research Enablement and Productivity Platform (REAP), version 2.0. Released 2022, India: Available from: https://reapv2.coguide.in/.
[22] Horenstein MS, Guillaume M. Tetralogy of Fallot. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Dec 27]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK513288/.
[23] Upadhyay V, Nayak P, Patel R, Lukhi S. Study of right ventricular outflow tract gradient in immediate postoperative period following intracardiac repair for tetralogy of Fallot. Heart India. 2023;11(2):57.
[24] Kaushal SK, Radhakrishanan S, Dagar KS, Iyer PU, Girotra S, Shrivastava S, et al. Significant intraoperative right ventricular outflow gradients after repair for tetralogy of Fallot: To revise or not to revise? Ann Thorac Surg. 1999;68(5):1705-12; discussion 1712-1713.
[25] Khan MS, Jan A, Ahmed H, Khan M, Khan AD, Shakil R, et al. Outcomes of surgical repair of tetralogy of fallot: A comparison between the adult and pediatric population. Cureus. 2023;15(7):e41467.
[26] Sadiq A, Shyamkrishnan KG, Theodore S, Gopalakrishnan S, Tharakan JM, Karunakaran J. Long-term functional assessment after correction of tetralogy of Fallot in adulthood. Ann Thorac Surg. 2007;83(5):1790-95.
[27] Bronicki RA, Checchia PA, Anas NG, Adams GJ, Penny DJ, Bleiweis MS, et al. Cerebral and somatic oxygen saturations after repair of tetralogy of Fallot: Effects of extubation on regional blood flow. Ann Thorac Surg. 2013;95(2):682-86.
[28] Massin MM, Malekzadeh-Milani SG, Schifflers S, Dessy H, Verbeet T. Long-term electrocardiographic follow-up after repair of tetralogy of fallot. Ann Noninvasive Electrocardiol Off J Int Soc Holter Noninvasive Electrocardiol Inc. 2011;16(4):336-43.

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- iThenticate Software: Jun 25, 2025 (12%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

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