Abnormalities of Conduction after total correction of Fallot's Tetralogy: a Prospective Study

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Abstract

Objective: To determine the frequency of post-operative conduction abnormalities in Pakistani patients undergoing total correction for Fallot's Tetralogy.

Patients and Methods: One hundred and fifteen patients of Fallot's Tetralogy underwent definitive repair between January,1999 and April, 2000. Their mean age was 12.89 years (range 3-30 years). One hundred nine patients (94.78%) had severe cyanosis and 6 patients (5.21%) were moderately cyanotic due to mild right ventricular outflow tract (RVOT) obstruction. Thirty percent patients required frequent hospital admissions within 6 months before the time of operation due to -hyper-cyanotic spells. The mean haematocrit was 50.83 (range 28-71). The majority of patients were in NYHA class-III (57%) and 45% had previous palliative shunt procedures done. Surgical access was through the RVOT in 90% cases and trans-atrial in 10%. RVOT patch was used in 55.9%, Pulmonary artery patch in 13.5% and trans-annular patch in 17.1% of cases.

Results: The mean bypass time was 79.15 min and the mean cross clamp time 51.23 min. Average stay in the intensive care unit was 4.48 days. Twenty-three patients required re-exploration for bleeding. Sixty-nine patients required inotropic support. Fifteen patients had transient heart blocks and two had complete heart block requiring permanent pace-maker. Nineteen patients had various transient arrhythmias which were managed medically. Univariate analysis showed that higher age at operation, low preoperative heart rate, prolonged bypass time, prolonged cross clamp time and presence of patch on pulmonary artery were more common in patients who developed various heart blocks. However, none of these factors had statistical significance or definitive cause-effect relationship with heart blocks.

Conclusion: With careful surgical technique, total correction of Fallot's tetralogy can be conducted in children and young adults, with a very low risk of conduction abnormalities (JPMA 52:77;2002).

Introduction

Surgical correction of the Fallots' Tetralogy (TOF) is one of the commonest operations in paediatric cardiac surgery. However, there are still controversies regarding the surgical approach and the optimal age for operation. Most of the surgeons in the developed world prefer to operate earlier as a one stage procedure. The definitive repair in infancy have been reported to carry low mortality and morbidity[1-4]. However, in developing countries like Pakistan, staged repair is still practised due to various limitations. Total correction in older children and young adults is very challenging. The repair through right atrium alone becomes technically difficult and right ventriculotomy is required quite frequently[5]. Since very few adult cases of Fallot's Tetrology are seen in the developed world, there is very little information about the results and post-operative problems of surgery in this age group. The largest series of over 800 such cases was reported by John et al.[6] which showed 0.4% incidence of complete heart block. This study however, does not provide any information about the risk factors for conduction defects. This study was done to determine frequency of the post-operative incidence of conduction abnormalities and to identify any possible incremental risk factors.

Patients and Methods

Patient Characteristic

From January 1999 to April 2000, 115 cases of TOF underwent total correction at National Institute of Cardiovascular Diseases, Karachi.

Standard cardiopulmonary bypass with hypothermia to 28° C and cold crystalloid cardioplegia was used in all patients. In patients with perimembranous VSD, right ventriculotomy was used to access the VSD. Incision was made either transverse or vertical depending upon anatomy of coronary arteries. However in VSDs extending more towards inflow tract, trans-atrial approach was used. The resection of RVOT was done by excising parietal band. The dissection was then carried upwards, dividing all obstructing muscle bands and excising the fibrous tissue. The main pulmonary artery was opened longitudinally only if it was small i.e. size two standard deviation or more below the normal mean size for the patients. Pulmonary valvotomy was performed by incising through the existing

commissures. The adequacy of the right ventricular outflow tract was assessed either visually or in doubtful cases by passing a Hegar's dilator of adequate size for age and body weight and body surface area. The pulmonary valve annulus was saved wherever possible. A patch of Dacron was used to repair VSD. Double ended 5/0 prolene (Ethicon) on 16 mm round body needle was used for stitching. Majority (90%) of patients had perimembranous VSDs. In small VSDs with entirely membranous posteroinferior rim we used pledgetted interrupted mattress sutures, stitched upto the middle of the superior rim of crista supra ventricularis then leading onwards by continuous over and over stitching for the rest of the VSD. In VSDs with muscular postero inferior rim, we used continuous over and over stitching all around. Any gross leak was checked by injecting saline through the LV vent passed via right superior pulmonary vein at the beginning of the operation. Since, in the region of posterio-inferior rim of VSD the conduction tissue lies in the left ventricular side, we used superficial bites. The RVOT and the pulmonary artery were closed with autologous pericardial patch whenever required. All patients were electively ventilated and stayed in the intensive care unit for customary 24-48 hours for invasive monitoring.

Follow-up was conducted by the surgical team at six weeks, three months, six months and one year. The clinical evaluation was supplemented with ECG and echocardiography. Six months follow-up was complete in 100% cases and the median follow up was 12 months. Data was collected by filling the individual forms and electronic data sheet (Excel 97).

Statistical Analysis

Data was analysed using SPSS software. Descriptive statistics i.e. frequencies, mean, medians, standard deviations and 95% confidence intervals were calculated for all preoperative and post-operative variables. Univariate analysis was done using student's t test for continuous variables and chi-square (χ^2) test for categoric variable and Fisher's exact test was used where ever necessary (Tables 4 and 5). The correlation between heart block and categoric variables was assessed by using Phi-statistics (ϕ). The level of significance for all these test results was set at P value of <0.05 .

Results

There were 77 males (66.95%) and 38 females (33.04%). The mean age at the time of the operation was 12.89 years with a standard deviation of 5.02 years (range 3-30 years). The frequency distribution of ages is shown in the histogram (Figure).

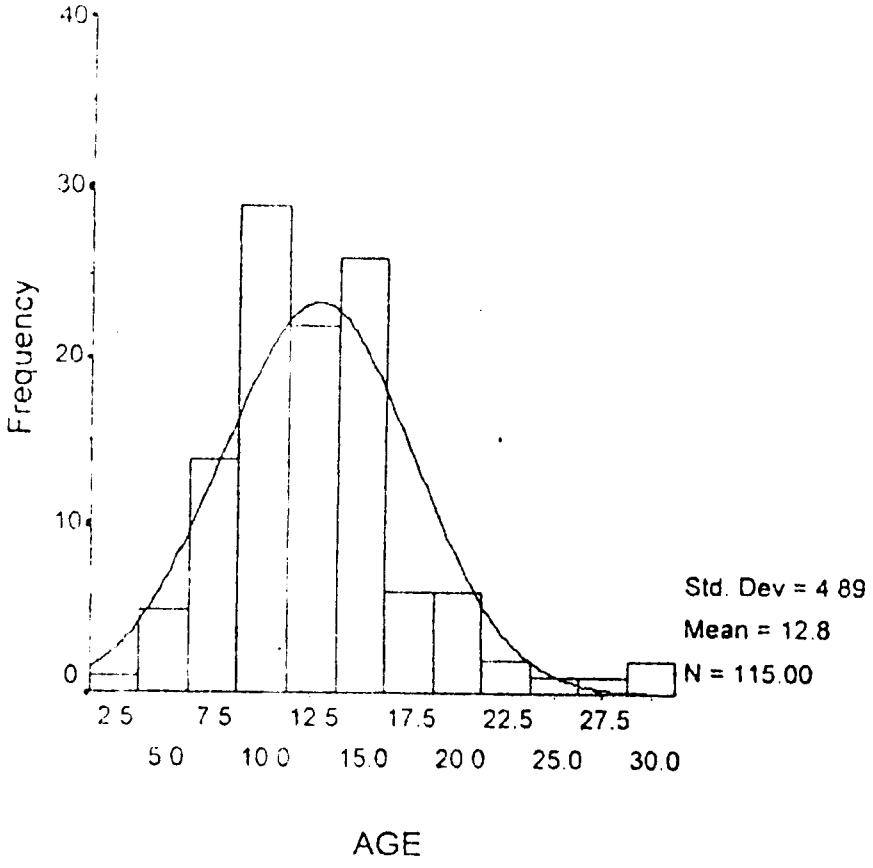

Figure. Frequency distribution of ages.

The associated cardiac anomalies were found in 54 patients (46.95%) included patent foramen ovale (PFO), atrial septal defect (ASD), patent ductus arteriosus (PDA) and multiple small ventricular septal defects (VSD). Anomalies of coronary arteries were detected in 12 patients (10.43%). Severe cyanosis was found in 109 patients (94.78%) and 6 patients (5.21%) had moderate cyanosis as their RVOT obstruction was not very severe. Thirty percent patients had repeated cyanotic spells requiring emergency hospital admissions within 6 months before the time of operation. The mean haematocrit was 50.83% (range 28-71%). Majority of the patients were in NYHA class-III (57%). Fourtyfive percent patients had previous shunt procedures. The pre-operative patient characteristics are summarised in Table 1.

Table 1. Preoperative characteristics.

Variables	Statictics	
Age (years)		
Mean	12.97	
Median	12.00	
Standard Deviation	04.89	
Range	03 - 30	
Sex	No.	%
Male	77	62.9
Female	38	30.9
NYHA status		
Class II	41	33.3
cLASS III	65	52.8
Class IV	09	07.3
Heart rate beats/min		
Mean	94	
Standard Deviation	12.7	
Range	70-140	
Cyanosis	115	100
Cyanotic spells	81	70.4
Haemoglobin gm/dl		
Mean	16.80	
Standard deviation	03.66	
Packed cell volume (%)		
Mean	50.83	
Standard deviation	09.15	
Range	28-71	
Serum sodium mmol/l		
Mean	138.60	
Standard deviation	03.46	
Serum potassium mmol/l		
Mean	3.88	
Standard deviation	0.45	
RVOT gradiant mmHg		
Mean	90.60	
Standard deviation	16.59	
Range	55 - 190	
Associated anomalities		
Abnormal conus artery	5	
Abnormal RCA	3	
Abnormal LAD	2	

The operative procedure in all cases was uncomplicated. The average bypass time was79.70 minutes (range: 50-240 minutes) , the cross clamp time was 51.91 minutes (range: 26-100 minutes). The bypass and the cross-clamp times were similar in both groups i.e. with or without rhythm/conduction abnormalities (Table 2).

Table 2. Operative variables.

Variables	Statistics	
Operative		
Bypass time minutes		
Mean	79.70	
Standard deviation	22.12	
Range	50 - 240	
Cross clamp time		
Mean	51.91	
Standard deviation	14.55	
	No.	%
Transannular patch	62	50.4
Non transannular RVOT patch	02	01.7
PA patch	17	13.8

Out of 115 total patients, 85 patients (69.1%) remained in normal sinus rhythm. Whereas 28 (22.8%) developed temporary conduction abnormalities but remained haemodynamically stable and were treated with temporary pacing for a period between 1-7 days. Only 2 patients developed complete heart block and required permanent pacemaker insertion after being on temporary pacemaker for 3 weeks. Various types of heart blocks were observed in other patients. The mean ICU and hospital stays were 4.27 days (range 1-13) and 9 days (range 7-18 days) respectively. These were longer in patients who developed conduction abnormalities. However the difference did not reach statistical significance (Table 3).

Other postoperative complications include re-exploration for bleeding, renal impairment, hypoxia, pneumothorax and pleural effusion. All these had uniform distribution in both groups i.e., with or without conduction abnormalities. No patient in this study developed any neurological complication (Table 3).

Fourteen patients (12.17%) died in the early postoperative period. None of these deaths were associated with any of the conduction abnormalities but due to biventricular failure in majority of the patients. The causes of death are given in Table 3.

Table 3. Postoperative variables.

Variables	Statistics	
Complications:	No.	%
Inotropic support required	73	59.3
Reoperation for bleeding	24	19.5
Hypoxia	26	22.6
Pneumothorax	5	04.1
Pleural effusion	12	04.1
Renal failure	18	14.6
Post-operative rhythm		
Sinus	85	69.1
Temporary heart block		
1st degree AV block (PR interval >2 ms)	5	04.1
2nd degree AV block	3	02.4
3rd degree AV block	6	06.5
Right bundle branch block (RBBB)	10	08.1
Permanent 3rd degree AV block	2	01.6
Temporary pacing required	28	22.8
Permanent pacemaker required	02	01.6
No of days in ITU		
Mean	4.27	
Median	4	
Standard deviation	1.95	
Range	1 - 13	
Deaths	14	12.17
Cause of death		
Cardiac Failure	10	8.69
Ventricular arrhythmias	2	1.74
Renal failure	1	0.87
Septicaemia	1	0.87

Discussion

Surgical correction of Fallot's Tetrology can be carried out as early as the first year of life[7,8] with low mortality and morbidity[9,10]. However in a developing country like Pakistan, two-stage repair involving initial shunt procedure at infancy followed by delayed surgical repair is still practiced, due to limitation in the intensive care management of infants. In the developed countries two-stage repair is only indicated in cases with pulmonary atresia, an associated very small right or left pulmonary artery, or an anomalous coronary artery. The initial shunt procedure provides some time for the pulmonary vasculature to develop to normal size. Interventricular septum and specially the margins of the ventricular septal defect becomes thicker and technically it becomes easier to take superficial bites at the posteroinferior rim of the VSD by avoiding injury to the conduction system which lies on the left ventricular side of the rim of the VSD. The low incidence (2 patients, 1.7%) of the permanent postoperative heart block can be attributed to the relatively older age (mean 12.9 years) of patients in this study.

Although grown up children can cope well with complicated intra-cardiac repair procedure, total correction in older children and young adults is a very challenging job. The massive right ventricular hypertrophy completely obscures the morphology of defects hence making the exposure of VSD technically difficult. In majority of these patients, satisfactory repair through right atrium alone is technically difficult and right ventriculotomy is required quite frequently.

There is evidence that transventricular approach increases the risk of ventricular arrhythmias and bundle branch blocks[11-13]. Nevertheless, transventricular approach has been used for many years and is still in use with good results by some surgeons[14]. Marco et al[15] have recommended the use of right ventriculotomy in patients with hypoplastic right ventricular outflow tract. The right ventriculotomy rate in their series was 31.8%. However, avoiding a ventriculotomy is very appealing and many authors have proposed a transatrial or transatrial-plus-transpulmonary approach as the preferred route of access in all cases[16-18].

The incidence of arrhythmias quoted in literature is highly variable. The commonest form of arrhythmia after total correction is multiple ventricular ectopics which can give rise to runs of ventricular tachycardia or even ventricular fibrillations[19,20]. The commonest conduction defect following repair is the right bundle branch block (RBBB). Its incidence alone or in combination with left anterior hemi block has been reported between 40-100% and 8-22% respectively[21]. We noticed RBBB in 8.1% and RBBB with left anterior hemi block in 2.4% of our cases. An injury to right bundle branch (RBB) can occur at three levels[22]. The first level of injury is at the septal portion of the right bundle branch (i.e.proximal RBBB). This usually occurs during repair of VSD in its posteroinferior portion. The 2nd level of injury i.e., distal RBBB, is at the moderator band. This can occur during resection of the muscle below the level of the VSD (the trabecula septomarginalis). The 3rd level of injury i.e. terminal RBBB is due to the transection of all major branching systems of right bundle branch at the junction of the moderator and parietal band. This occurs during extensive ventriculotomy or infundibulectomy through transatrial approach.

The site of injury can be determined non-invasively by echocardiography by measuring the time taken by the

cardiac impulse to travel from the AV node to the apex of the right ventricle i.e. V-RVA interval. This is longer than 35msec in proximal right bundle branch block but normal in terminal RBBB[23]. The RBBB alone has very limited clinical significance and does not require any treatment. The other types include different degrees of AV blocks and the combination of RBBB and LAH which is frequently associated with symptoms like syncopal attacks and requires insertion of permanent pacemaker. Very little is known about the risk factors that can predict the development of heart block after the operation. We studied large number of preoperative and operative variables to find out any possible incremental risk factors. A complete list of these variables is given in Tables 1 and 2.

In the univariate analysis, we noticed that patients who developed heart blocks, had higher preoperative RVOT gradient and longer bypass as well as cross-clamp time than those who did not develop heart blocks. However the P-values of differences between these groups remained above 0.05 making them statistically insignificant. More over the prolonged bypass and cross clamp time resulted in temporary conduction defects which recovered without requiring pacemaker insertion. This study also shows that patients who developed conduction problems after operation had mean preoperative heart rate of 80/min whereas those who remained in sinus rhythm without any block and mean heart rate of 97/min. This is an interesting observation, however, the study does not provide any evidence that what heart rate is low enough to definitely produce a heart block after the operation.

This study does not show very strong association between any pro or peroperative variable with the development of heart block (Table 4). A closer look at the data reveals that findings like higher preoperative RVOT gradient and longer bypass and cross clamp times in heart block group indirectly indicate complexity and difficulty of procedure. In other words the main factor in the development of conduction disorders is difficult morphology of disease (Table 5). If such is the case, the only way to prevent rhythm complications and heart blocks is to use an extreme degree of surgical care utilizing the thorough knowledge of anatomy of conduction tissue and the pathological morphology of this disease.

Table 4. Student's t test for comparison of continuous variables.

Variables	No heart block mean (S.D.)	Heart block mean (S.D.)	P. value
Pre-operative			
Age in years	12.36 (5.6)	14.01 (4.2)	0.10
Heart rate beats/min	96 913.68)	88 (6.73)	0.07
Haemoglobin gm/dl	17.08 (3.7)	16.14 (3.3)	0.24
Packed cell volume %	51.53 (8.53)	48.64 (10.72)	0.15
RVOT gradient mm Hg	89.43 (11.75)	94.46 (26.51)	0.16
Operative and post-operative			
Bypass time in minutes	78.10 (22.41)	84.46 (20.82)	0.17
Cross clam time in minutes	50.52(13.42)	56.21 (17.16)	0.07
ITU stay	04.06 (17.2)	04.89 (2.28)	0.05

Table 5. Chi-square test for comparison of categoric variables.

Variable	(No) heart block	Heart block	P (χ^2)	P (ϕ)
Pre-operative				
Male: female	58:29	19:09	0.91	0.91
Cyanotic spells	27	7	0.54	0.54
NYHA (II/III/IV)	29/49/9	12/16/0	0.18	0.18
Operative and post-operative				
Pulmonary artery patch	17	0	0.01	0.01
Transannular patch	43	19	0.13	0.13
RVOT patch	48	16	1.00	1.00
Postoperative hypoxia	23	3	0.12	0.12

We conclude that children and young adults with Fallot's tetralogy can undergo total correction with very low rate of postoperative rhythm problems. The heart block can be avoided by taking care of the anatomy of the conduction system and by using interrupted stitches in the region of the conduction bundle.

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