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# INCIDENCE AND SEVERITY OF ARRHYTHMIAS AND CONDUCTION DISTURBANCE AFTER REPAIR OF TETRALOGY OF FALLOT*

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**Ventricular and supraventricular arrhythmias and conduction disturbances were evaluated by routine electrocardiography and 24-hour ambulatory monitoring in 31 patients who underwent correction of tetralogy of Fallot. The interval from operation to the study was 1 month to 14 years (mean 4.8 ± 2.8). Complete right bundle branch block occured in 22 (71%) patients and incomplete right bundle branch block in 9 (29%) patients. Bifascicular block with right bundle branch block and left axis deviation (LAD) occurred in one patient. Two patients had second degree type II atrioventricular block. Twenty-four-hour ambulatory electrocardiographic monitoring was performed in all patients and they were divided in two groups according to the frequency of ventricular arrhythmias (Lown classification). Group 1 included the 23 patients who had no arrhythmia or rare ventricular arrhythmias (Lown grade 0-1). Group 2 was comprised of eight patients (26%) with significant ventricular arrhythmias (Lown grade 2-5). Twelve patients (39%) had supraventricular arrhythmias, three patients rare supraventricular tachycardia attacks, and seven patients occasional supraventricular ectopies. One patient had bradycardia-tachycardia attacks and one patient had junctional tachycardia. There was no correlation between age at the time of surgery and ventricular arrhythmias. Of the patients who had ventricular and supraventricular arrhythmias of various degrees on ambulatory monitoring, two had significant arrhythmias on routine electrocardiogram. Symptoms were rare in these patients. In conclusion, both supraventricular and ventricular arrhythmias were found in considerable frequency in our patients. As ventricular arrhythmias may be the cause of sudden death and supraventricular arrhythmias are a main cause of morbidity, it is important to evaluate ventricular and supraventricular arrhythmias by ambulatory monitoring in patients who have undergone correction of tetralogy of Fallot.**
*Key words: ventricular arrhythmia, supraventricular arrhythmia, tetralogy of Fallot, conduction disturbance, ambulatory monitoring, electrocardiography.*

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Postoperative ventricular arrhythmia and conduction disturbances are common after repair of tetralogy of Fallot[1-3]. Tetralogy of Fallot (TF) is the most comon cause of sudden death in children among the other postoperative congenital heart diseases[4]. Sudden death is related to ventricular tachyarrhythmias or progressive abnormalities of atrioventricular conduction and complete atrioventricular block[5]. While on routine electrocardiograms (ECG), 10 percent of patients have ventricular arrhythmias, this prevalence increases to 50 percent on Holter ECG[2,6,7]. Right bundle branch block (RBBB) is the most common conduction disturbance after intracardiac repair of many of the cardiac defects[8]. Although this condition in itself is benign, RBBB and left anterior hemiblock together may have a poor prognosis, with a significantly increased incidence in this group of late complete heart block and sudden death[9]. Supraventricular arrhythmias in postoperative TF have rarely been mentioned in previous reports and thus the pathologic significance of these arrhythmias is not well documented.

The purpose of this study is to evaluate the prevalence of ventricular and supraventricular arrhythmias and conduction defects, in addition to the factors that can effect them, in patients with repair of TF.

## Material and Methods

Patients: The study involved 31 patients who underwent correction of TF at Başkent and Hacettepe University Hospitals between 1982-1995. The age of patients at the time of corrective surgery was 1.5 to 13 years (mean 4.4 ± 2.6). The interval from operation to the study was 1 month to 14 years (mean 4.8 ± 2.8). Two patients had previously undergone a Blalock-Taussig operation. No patient had undergone reoperation. In all patients, the conventional operative method was closure of the ventricular septal defect (VSD) with a teflon patch with right ventriculotomy and reconstruction of the pulmonary outflow tract. Physical examination and echocardiographic study were performed in all patients for evaluation of presence of residual VSD, pulmonary valve insufficiency or right ventricular outflow obstruction. All patients had 12-lead electrocardiograms during the follow-up period. The tracings were analyzed for the presence of ventricular and atrial arrhythmias and conduction disturbances. QRS intervals in the right precordial leads greater than 120 milliseconds with terminal conduction delay were defined as right bundle branch block (RBBB). Incomplete right bundle branch block (IRBBB) was diagnosed when the QRS duration was less than 120 milliseconds with terminal conduction delay. QRS axis between -30 and -120 was defined as left axis deviation. Twenty-four-hour ambulatory electrocardiographic monitoring was performed in all patients with Danica Holter System. Severity of ventricular arrhythmias (VA) was classified according to Lown Criteria (10): Grade 0: absence of ventricular extrasystoles in 24 hours, grade

1: uniform ventricular extrasystoles less than 30 in an hour, grade 2: more than 30 uniform ventricular extrasystoles in any hour, grade 3: multiforme ventricular extrasystoles less than 30 in an hour, or couplets (two consecutive ventricular extrasystoles), grade 4: couplets, or multiforme ventricular extrasystoles more than 30 in an hour, and grade 5: ventricular tachycardia (more than 3 consecutive ventricular extrasystoles). Patients were divided in two groups according to the significance of VA. Group I included 23 patients who had no arrhythmias or ventricular arrhythmias in Lown grade I. Group II was composed of eight patients with significant VA (Lown grade 2-5).

Statistical analysis was performed using the student's t test for comparison of the values between the two groups.

## Results

### *Clinical Status*

Group I was composed of 23 patients with grade 0-1 VA. Group II was composed of eight patients with grade 2-5 VA. There was no significant difference between the two groups regarding age at the time of corrective surgery and interval from surgery to this study (Table I), although ventricular ectopy was more often seen in patients who had undergone surgery more than five years before. According to echocardiographic findings, there was no difference between the two groups. Five patients (16%) had symptoms such as chest pain, fatigue or palpitation (4 of them were in Group II). Symptoms were attributed to arrhythmias, as none of the patients had significant hemodynamic disturbance.

Table I: Clinical Differences Between the Two Groups

| | Group I (n: 23) | Group II (n: 8) | p |
|---|---|---|---|
| age at op. (yr) | 4.5 ± 2.5 | 4.4 ± 2.7 | > 0.05 |
| interval from op. (yr) | 4.4 ± 3.1 | 5.5 ± 2 | > 0.05 |
| symptom free | 22 (95%) | 4 (50%) | < 0.01 |

### *Electrocardiograms*

Postoperative resting ECGs showed RBBB in 71 percent of the patients and IRBBB in 29 percent of the patients. Bifascicular block (RBBB and LAD) occurred in one patient. Neither ventricular nor supraventricular ectopy was detected in any of the patients. In Group I, one patient had first degree and one patient second degree, type II atrioventricular block. Bradycardia-tachycardia attacks were detected in one patient on surface ECG. There was no progressive conduction defect during follow-up period. Postoperative conduction defects on ECG are shown in Table II.

Table II: Conduction Defects on Post Operative Electrocardiograms of the Two Groups

| Conduction Defects | Group I (n: 23) no. of pts. | Group II (n: 8) no. of pts. |
|---|---|---|
| RBBB | 16* | 6** |
| IRBBB | 7 | 2 |
| RBBB + LAD | 1 | 0 |
| AVB | 2 | 0 |
| SND | – | 1 |

* These patients also include the patient with RBBB + LAD and the patients with first degree and second degree AVB.

** These patients include the patient with SND.

RBBB : complete right bundle branch block.
IRBBB : incomplete right bundle branch block.
LAD : left axis deviation.
AVB : atrioventricular block.
SND : sinus node dysfunction.

*Ambulatory Monitoring*

Eight patients (26%) had significant VA of grade 2-5. Eight patients had VA of grade 1 and 15 patients had no VA (grade 0) in 24-hour monitoring. Supraventricular arrhythmias were detected in 12 patients (39%). Three patients had rare supraventricular tachycardia attacks and seven patients had supraventricular ectopy. Sinus pause less than 2.6 seconds was detected in two patients with supraventricular ectopy. One patient had bradycardia-tachycardia attacks (sinus node dysfunction), and junctional tachycardia was detected in one patient (Figs 1, 2).


Fig. 1: Bradycardia-tachycardia attacks of a patient.

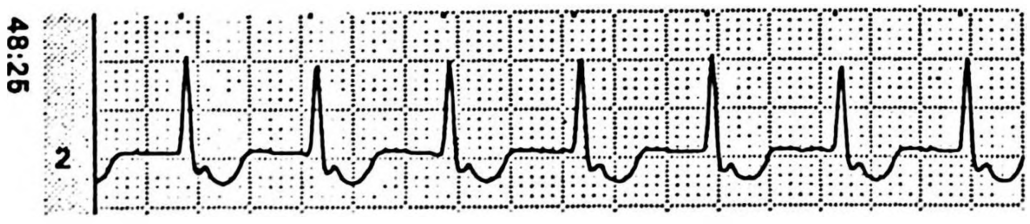


Fig. 2: Nodal (junctional) tachycardia. Note the inverted P waves after each QRS complex, with a heart rate of 130 beats per minute.

Lown classification of VA related to supraventriclar arrhythmias is shown in Table III: Five patients with grade 0; five patients with grade 1, and two patients with grade 5 also had supraventricular arrhythmias. Supraventricular arrhythmias were not found to be related to the frequency of VA.

Table III: Lown Classification of Ventricular Arrhythmias Related to Supraventricular Arrhythmias

| | Lown Classification of VA | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |
| SVET | | 3 | | | | |
| SVE | 3 | 2 | | | | 2 |
| SND | 1 | | | | | |
| Nodal t. | 1 | | | | | |

VA : Ventricular arrhythmia. SVT : Supraventricular tachycardia.
SVE : supraventricular ectopy. SND: sinus node dysfunction.
Nodal t.: nodal tachycardia.

## Discussion

Patients who have undergone repair for TF have a higher incidence of VA than the normal population, and these patients are at an increased risk for sudden death[11, 12]. Late sudden death caused by VA has been reported in up to five percent of cases where patients have undergone surgical repair of TF[13]. While earlier studies suggested that late cardiac arrest was related to the progression of bifascicular block to complete heart block[9, 14], in recent years, late sudden death after the correction of TF has been attributed to ventricular dysrhythmias[6, 15]. In recent reports, ventricular extrasystoles during ambulatory monitoring or exercise test, presence of ventricular late potentials, inducible ventricular tachycardia[16-18] and prolonged QRS duration[19] are all considered indicators of increased risk for life-threatening VA inpostoperative tetralogy.

Spontaneous VA occurs during ambulatory ECG monitoring in 20-50 percent of patients with surgically corrected TF[10]. In this study, 38 percent of the patients had various degrees of VA on ambulatory monitoring. Significant VA was found in 26 percent patients (Group II). This result is almost the same as in previous reports[2, 3, 7].

In our study, age at the time of surgery and the interval from surgery to the study did not differ statistically between the two groups. Previous reports suggest that the onset of VA is age related. Bove et al.[20] reported that age at the time of surgery was higher in patients with VA than in those without VA. James et al.[21] and Kato et al.[22] also showed increased frequency of VA in older patients who underwent correction of TF. These findings may suggest progressive fibrotic change in the right ventricle[23, 24].

In previous reports, VA and sudden death were correlated with hemodynamic disturbances and raised right ventricular pressure[7, 25]. However, we did not find such a correlation between VA and hemodynamic status, as none of our patients had significant hemodynamic disturbance. In the pediatric population, RBBB pattern is the most common interventricular conduction defect following open heart surgery. It has been reported to occur in 60-100 percent of cases, following repair of TF[8, 26].

The mechanism leading to RBBB in most of these patients was proximal disruption of right bundle due to closure of VSD or distal injury caused by right ventriculotomy[27, 28]. In our study, RBBB was detected in 71 percent and incomplete RBBB in 29% percent of the patients. In the present study, supraventricular arrhythmias were detected on ambulatory monitoring in 12 (39%) patients and these were not considered as hemodynamically significant. Previous studies have stressed the incidence and role of ventricular arrhythmias in post operative TF, with supraventricular arrhythmias rarely mentioned. Recently, Hesselink et al.[29] detected atrial arrhythmias in one-third of their adult patients who underwent correction of TF. Ventricular arrhythmias are well known to be the cause of sudden death, while supraventricular arrhythmias are not related to death, but are considered as the main cause of morbidity in the patients who underwent correction of TF.

In conclusion, we found various degrees of VA in 51 percent and supraventricular arrhythmias in 39 percent of our patients on Holter monitoring. The majority of these patients were asymptomatic. Although there was no significant difference between the two groups in age at the time of surgery and the time interval from surgery to this study, ventricular ectopy was more often seen in patients who had undergone surgery five years or more before. Because both types of arrhythmias are not always present on surface ECGs, it is important to evaluate arrhythmias in these patients during follow-up by ambulatory monitoring.

## REFERENCES

1. Deanfield JE, McKenna WJ, Hallidie-Smith KA. Detection of late arrhythmia and conduction disturbance after correction of tetralogy of Fallot. Br Heart J 1980; 44: 248-253.
2. Kavey RE, Blackman MS, Sondheimer HM. Incidence and severity of chronic ventricular dysrhythmias after repair of tetralogy of Fallot. Am Heart J 1982; 103: 342-350.
3. Chandar JS, Wolff GS, Garson A Jr, et al. Ventricular arrhythmias in post operative tetralogy of Fallot. Am J Cardiol 1990; 65: 655-661.
4. James FW, Kaplan S, Chou TC. Unexpected cardiac arrest in patients after surgical correction of tetralogy of Fallot. Circulation 1975; 52: 691-695.
5. Garson A Jr, McNamara DG. Sudden death in pediatric cardiology population, 1958 to 1983: relation to prior arrhythmias. J Am Coll Cardiol 1985; 5: 134B-137B.
6. Garson A Jr, Gillette PC, Gutgesell HP, Mc Namara DG. Stress-induced ventricular arrhythmia after repair of tetralogy of Fallot. Am J Cardiol 1980; 46: 1006-1012.

7. Kobayashi J, Hirose H, Nakano S, et al. Ambulatory electrocardiographic study of the frequency and cause of ventricular arrhythmia after correction of tetralogy of Fallot. Am J Cardiol 1984; 54: 1310-1313.
8. Dunnigan A, Pritzker MR, Benditt DG, Benson DW Jr. Life-threatening ventricular tachycardias in late survivors of surgically corrected tetralogy of Fallot. Br Heart J 1984; 52: 198-206.
9. Wolff GS, Rowland TW, Ellison RC. Surgically induced right bundle-branch block with left anterior hemiblock: an ominous sign in post-operative tetralogy of Fallot. Circulation 1972; 46: 587-594.
10. Ryan M, Lown B, Horn H. Comparison of ventricular ectopic activity during 24-hour monitoring and exercise test in patients with coronary heart disease. N Engl J Med 1975; 292: 224-229.
11. Vaksmann G, Fournier A, Davignon A, Ducharme G, Houyel L, Fouron JC. Frequency and prognosis of arrhythmias after operative "correction" of tetralogy of Fallot. Am J Cardiol 1990; 66: 346-349.
12. Cullen S, Celermajer DS, Franklin RC, Hallidie-Smith KA, Deanfield JE. Prognostic significance of ventricular arrhythmia after repair of tetralogy of Fallot: a 12-year prospective study. J Am Coll Cardiol 1994; 5: 1151-1155.
13. Murphy JG, Gersh BJ, Mair DD, et al. Long-term outcome in patients undergoing surgical repair of tetralogy of Fallot. N Engl J Med 1993; 329: 593-599.
14. Marin-Garcia J, Moller JH: Sudden death after operative repair of tetralogy of Fallot. Br Heart J 1977; 39: 1380-1386.
15. Garson A, Nihill MR, McNamara DG, Coley DA. Status of the adult and adolescent after repair of tetralogy of Fallot. Circulation 1979; 59: 1232-1236.
16. Waksmann G, Elkohen M, Lacroix D, Kacet S, Breviere GM. Influence of clinical and hemodynamic characteristics on signal-averaged electrocardiograms in post operative tetralogy of Fallot. Am J Cardiol 1993; 71: 317-321.
17. Zimmermann M, Friedli B, Adamec R, Oberhänsli I. Ventricular late potentials and induced ventricular arrhythmias after surgical repair of tetralogy of Fallot. Am J Cardiol 1991; 67: 873-878.
18. Giroud D, Zimmermann M, Adamec R, Oberhänsli I, Friedli B. Ventricular late potentials and spontaneous ventricular arrhythmias after surgical repair of tetralogy of Fallot: do they have prognostic value? Br Heart J 1994; 72: 580-583.
19. Gatzoulis MA, Till JA, Somerville J, Redington AN. Mechanoelectrical interaction in tetralogy of Fallot QRS prolongation relates to right ventricular size and predicts malignant ventricular arrhythmias and sudden death. Circulation 1995; 92: 231-237.
20. Bove EL, Byrum CJ, Thomas FD, et al. The influence of pulmonary insufficiency on ventricular function following repair of tetralogy of Fallot. Evaluation using radionuclide ventriculography. J Thorac Cardiovasc Surg 1983; 85: 691-696.
21. James FW, Kaplan S, Schwartz DC, Chou T, Sandker M, Naylor V. Response to exercise in patients after total surgical correction of tetralogy of Fallot. Circulation 1976; 54: 671-679.
22. Kato M, Kawashima Y, Fujita T, Mori T, Manabe H. Right ventricular hypertrophy in tetralogy of Fallot. Recent advances in studies on cardiac structure and metabolism. Recent Adv Stud Cardiac Struct Metab 1976; 12: 149-155.
23. Jones M, Ferrans VS. Myocardial degeneration in congenital heart disease. Comparison of morphologic findings in young and old patients with congenital heart disease associated with muscular obstruction to right ventricular outflow. Am J Cardiol 1977; 39: 1051-1055.
24. Misaki T, Tsubota M, Watanabe G, et al Surgical treatment of ventricular tachycardia after surgical repair of tetralogy of Fallot. Relation between intraoperative mapping and histological findings. Circulation 1994; 90: 264-271.

25. Karademir S, Özkutlu S, Özme Ş, Saraçlar M, Özer S, Bilgiç A. Tüm düzeltme uygulanan Fallot tetralojili hastaların hastane mortalitesi, postoperatif rezidüel defekt ve komplikasyonları. Türk Kardiyol Dern Arş 1992; 20: 55-59.

26. Ehud K. Prognosis for patients with congenital heart disease and post-operative intraventricular conduction defects. Circulation 1978; 57: 867-869.

27. Titus JL, Daughterty GW, Kirklin JW, Edwards DE. Lesion of the atrioventricular conduction system after repair of ventricular septal defect: relation to heart block. Circulation 1963; 28: 82-88.

28. Horowitz LW, Simson MB, Spear JF. The mechanism of apparent right bundle-branch block after transatrial repair of tetralogy of Fallot. Circulation 1979; 59: 1241-1252.

29. Hesselink JR, Perlroth MG, McGhie J, Spituels S. Atrial arrhythmias in adults after repair of tetralogy of Fallot. Circulation 1995; 91: 2214-2219.