

Incidence and Severity of Ventricular Arrhythmia in Patients after Repair of Tetralogy of Fallot

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SUMMARY

To evaluate the incidence and severity of ventricular arrhythmias (VA) in a large group of patients who underwent corrective surgery for tetralogy of Fallot (TF) more than 4 years previously (mean age at surgery: 6 years 5 months), cardiac catheterization and cineangiography as well as 24 hour ambulatory Holter electrocardiography (HE) were performed in 45 patients.

Fifteen (33%) of the 45 patients had VA of Lown grade 2 or greater. Patients with VA (group I) were found to be significantly older at surgery than patients without VA (group II) ($p < 0.05$). There were no significant differences in the ratio of postoperative right and left ventricular systolic pressures (RVSP/LVSP), and also right ventricular ejection fraction (RVEF) between the 2 groups.

As far as we know, none of our patients has suffered a sudden late death after repair of TF. Still, the overall incidence of VA was significantly high.

Additional Indexing Words:

Tetralogy of Fallot Ventricular arrhythmia Holter monitoring

IT has been reported that 1 to 6 percent of patients after surgical repair of tetralogy of Fallot (TF) have suffered a late sudden death,^{1)–5)} and ventricular arrhythmias (VA) which are common in postoperative TF patients, have been considered as a cause.^{1)–4)} However, factors which predispose to the high incidence of VA in patients after TF repair remain controversial and previous reports suggest that early surgery may reduce the occurrence of this late complication.^{1)–4), 6)–8)}

We evaluated cardiac rhythm postoperatively using 24 hour ambulatory Holter electrocardiography (HE) in patients selected from a group who

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underwent corrective surgery of TF at a relatively early age (mean: 6 years 5 months).

SUBJECTS AND METHODS

The study population consisted of a total of 182 consecutive patients with TF, diagnosed at Kyushu University Hospital by cardiac catheterization and cineangiography, who underwent intracardiac repair during the 16 year period from 1966 to 1982. Those who died within 4 weeks after operation were excluded. Their ages at operation ranged from 2 years 2 months to 18 years 6 months (mean: 6 years 5 months), and their ages at the time of writing this report ranged from 7 years 5 months to 37 years (mean: 17 years 10 months). The interval from surgery ranged from 4 years 2 months to 20 years 9 months (mean: 10 years 11 months). From this group, 176 patients (97%) were successfully contacted and confirmed to have been free of serious complications, including late death.

In the present study, from among 176 patients HE, was performed in 45 patients. These patients were being followed mainly at our university hospital. No other selection criteria were employed. All patients on whom HE was performed underwent postoperative cardiac catheterization and cineangiography. No patient was taking cardioactive medication at the time of this study. Right and left ventricular volume characteristics were estimated from biplane cineangiograms by the area-length method. The incidence and severity of VA and its relation to factors such as the age at surgery, the interval from surgery, and postoperative cardiothoracic ratio at this study were evaluated. The severity of VA by HE was graded according to Lown's criteria.⁹⁾

The surgical procedure for correction of TF was similar in each patient and used cardiopulmonary bypass with right ventriculotomy for patch closure of the ventricular septal defect and resection of infundibular hypertrophy.

A p value of <0.05 was considered to be significant using Student's t-test.

RESULTS

Standard 12 lead electrocardiogram:

All 45 patients were in sinus rhythm. Complete right bundle branch block was present in 36 (80%) patients; 4 (9%) had left axis deviation (mean frontal QRS axis of $<-30^\circ$). Ventricular premature contractions (VPC) were present in 5 (11%) patients.

Severity of VA by HE (Table I):

Among the 45 patients evaluated by HE, no VPCs (grade 0) were detected in 20 (44%) patients. Grade 1 VA (occasional VPCs, but no more than 30 in any hour of monitoring) was found in 10 (22%) patients; grade 2 (more than 30 VPCs in any hour of monitoring) in 4 (9%); grade 3 (multiform VPCs) in 6 (13%); grade 4-a (couplets) in 2 (4%); grade 4-b (ventricular tachycardia, i.e., 3 or more VPCs in succession) in 3 (7%). In all 3 patients with grade 4-b, VA appeared at night during sleep. Four of 5 patients who had VPC on a standard 12-lead ECG had VA of Lown grade 2 or greater on HE.

Clinical/hemodynamic characteristics and late VPCs on HE (Table II):

Of 45 patients evaluated, there were 25 patients with late VA (group

Table I. Severity of Ventricular Arrhythmia by Ambulatory 24 Hour Holter ECG in Patients after Repair of TF (n=45)

Lown grade	Number of patients (%)
0	20 (44%)
1	10 (22%)
2	4 (9%)
3	6 (13%)
4-a	2 (4%)
4-b	3 (7%)
Total	45 (100%)

Table II. Characteristics in Patients with Late Ventricular Arrhythmias (Group I) and without (Group II) on Ambulatory 24 Hour Electrocardiogram (Holter ECG) after Repair of TF (n=45)

	Group I VPC(+), n=25	Group II VPC(-), n=20	p value
Age at surgery (yr)	6.1 \pm 3.5	4.2 \pm 1.5	p<0.05
Interval from surgery (yr)	8.7 \pm 4.5	7.0 \pm 3.4	n.s.
Preoperative hemoglobin (g/dl)	17.1 \pm 2.4	17.2 \pm 2.2	n.s.
Postoperative hemodynamics			
RVSP/LVSP	0.45 \pm 0.2	0.42 \pm 0.2	n.s.
RVEF (%)	54.6 \pm 7.6	53.1 \pm 11.2	n.s.
RVEDV (ml)	121 \pm 23	144 \pm 28	p<0.05
LVEF (%)	65.5 \pm 6.6	63.4 \pm 9.3	n.s.
Cardiothoracic ratio (%)	53.5 \pm 4.0	53.8 \pm 6.4	n.s.

VPC(+)=ventricular premature contraction, present; VPC(-)=VPC, absent; RVSP=right ventricular systolic pressure; LVSP=left ventricular systolic pressure; RVEF=right ventricular ejection fraction; RVEDV=right ventricular end-diastolic volume; LVEF=left ventricular ejection fraction; n.s.=not significant.

I) and 20 patients without VA (group II) on HE. The age at surgery was significantly higher in group I ($p < 0.05$). The interval from surgery was also longer in group I, but there was no significant difference between the 2 groups. Right ventricular end-diastolic volume (RVEDV) was significantly increased in group II ($p < 0.05$).

Operative methods and late VPCs:

According to the operative reports, all of the patients received right ventriculotomy, and neither the use of an outflow patch nor reoperation was significantly related to VPCs.

DISCUSSION

Earlier studies revealed that 30 to 75% of late deaths in patients after repair of TF were sudden, and arrhythmias, especially ventricular arrhythmias (VA), have been considered to be the cause.¹⁾⁻⁵⁾ In our series, VPC was detected with HE in 25 (56%) patients out of 45 in total, but it was found on standard 12-lead ECG in only 5 (11%) patients. Brodsky et al¹⁰⁾ detected VA with HE in 25 (50%) of 50 healthy medical students, but they reported that the incidence of multifocal VPCs was 12%. In our study, 24% had VA of Lown grade 3, i.e., multifocal VPCs or greater (Table I), indicating a clear difference from healthy subjects.

The fact that all 3 patients with VA of Lown grade 4-b, i.e., short runs of VPCs on HE had less than one hundred VPCs per day in total and that 2 of 3 patients had no VPC on standard 12-lead ECG and were completely free from subjective symptoms and complaints, suggests the necessity of careful observation postoperatively, even of patients with few PVCs. Dunnigan et al¹¹⁾ also stated that ambulatory ECG monitoring was normal in 2 of 3 patients and none of them had symptoms of exercise intolerance or congestive heart failure before the development of symptoms of life threatening ventricular tachycardia.

The incidence of 33% of VA of Lown grade 2 or greater in our patients is slightly lower but still comparable to those reported by Wessel et al¹²⁾ and Kavey et al,¹³⁾ who noted VA of Lown grade 2 to 4 with HE in 41% and 42% of their patients after repair of TF, respectively. The incidence is even higher in the study by Rosing et al who reported that 67% of their patients showed VA of grade 2 or greater after repair of TF.¹⁴⁾

Katz et al¹⁵⁾ reported that the age at surgery for TF largely influenced the occurrence of arrhythmias after operation, and that the frequency of arrhythmias in the patients operated on at 30 years of age was 17 times greater than that of patients who were 15 at the time of surgery. Similarly, patients

who were 5 years of age at surgery had 1.4 times the frequency of arrhythmias seen in patients 2 years of age at surgery. Although our patients underwent corrective surgery at relatively younger ages compared to the previous reports^{1)-4),6),12)-15)} and none of them has succumbed to sudden late death, still the overall incidence of VA was significantly higher than normal. Recently, Sullivan et al⁷⁾ reported that VA was already present preoperatively in 8 (45%) of 18 patients in an older group aged 13 to 43 years at the time of surgical repair and that VA could be part of the natural course of the disease and early surgery may reduce the occurrence of this late complication.

James et al¹⁴⁾ stated that the average age of patients at surgery for TF who showed VA on postoperative exercise testing was 15.6 years and that the VA at the exercise test reflected impaired cardiovascular function, i.e., depressed right ventricular function. But Deanfield et al⁸⁾ stated that late VA is related to the timing of surgery rather than to the operation itself or to residual hemodynamic abnormalities. In our study, also, there were no significant differences in the ratio of postoperative right and left ventricular systolic pressures (RVSP/LVSP), and right ventricular ejection fraction (RVEF) between the 2 groups.

VA in patients after repair of TF is closely related to the age at the time of surgical correction and no subjective symptoms and signs and/or no arrhythmia on a 12-lead standard ECG does not necessarily mean a low risk of developing a fatal arrhythmia. The higher the age at surgery and the longer the postoperative interval, the more careful a follow-up, especially rhythm evaluation, is necessary for all patients after repair of TF, regardless of clinical symptoms and signs.

REFERENCES

1. James FW, Kaplan S, Chou T: Unexpected cardiac arrest in patients after surgical correction of tetralogy of Fallot. *Circulation* **52**: 691, 1975
2. Quattlebaum TG, Varghese PJ, Neill CA, Donahoo JS: Sudden death among postoperative patients with tetralogy of Fallot. A follow up study of 243 patients for an average of twelve years. *Circulation* **54**: 289, 1976
3. Gillette PC, Yeoman MA, Mullins CE, McNamara DG: Sudden death after repair of tetralogy of Fallot. Electrocardiographic and electrophysiologic abnormalities. *Circulation* **56**: 566, 1977
4. Garson A, Nihill MR, McNamara DG, Cooley DA: Status of the adult and adolescent after repair of tetralogy of Fallot. *Circulation* **59**: 1232, 1979
5. Garson A, Gillette PC, Gutgesell HP, McNamara DG: Stress-induced ventricular arrhythmia after repair of tetralogy of Fallot. *Am J Cardiol* **46**: 1006, 1980
6. Kobayashi J, Hirose H, Nakano S, Matsuda H, Shirakusa R, Kawashima Y: Ambulatory electrocardiographic study of the frequency and cause of ventricular arrhythmia after correction of tetralogy of Fallot. *Am J Cardiol* **54**: 1310, 1984
7. Sullivan ID, Presbitero P, Gooch VM, Aruta E, Deanfield JE: Is ventricular arrhythmia in

- repaired tetralogy of Fallot an effect of operation or a consequence of the course of the disease? *Br Heart J* **58**: 40, 1987
8. Deanfield JE, McKenna WJ, Presbitero P, England D, Graham GR, Hallidie-Smith K: Ventricular arrhythmia in unrepaired and repaired tetralogy of Fallot. Relation to age, timing of repair, and haemodynamic status. *Br Heart J* **52**: 77, 1984
 9. Ryan M, Lown B, Horn H: Comparison of ventricular ectopic activity during 24-hour monitoring and exercise testing in patients with coronary heart disease. *New Engl J Med* **292**: 224, 1975
 10. Brodsky M, Kanakis C, Rosen KM: Arrhythmias documented by 24 hour continuous electrocardiographic monitoring in 50 medical students without apparent heart disease. *Am J Cardiol* **39**: 390, 1977
 11. Dunnigan A, Pritzker MR, Benditt DG, Benson DW Jr: Life threatening ventricular tachycardia in late survivors of surgically corrected tetralogy of Fallot. *Br Heart J* **52**: 198, 1984
 12. Wessel HU, Bastanier CK, Paul MH, Berry TE, Cole RB, Muster AJ: Prognostic significance of arrhythmia in tetralogy of Fallot after intracardiac repair. *Am J Cardiol* **46**: 843, 1980
 13. Kavey RW, Blackman MS, Sondheimer MH: Incidence and severity of chronic ventricular dysarrhythmia after repair of tetralogy of Fallot. *Am Heart J* **103**: 342, 1982
 14. Rosing DR, Borer LS, Kent KM, Maron BJ, Seldes SF, Morrow AG, Epstein SE: Long-term hemodynamic and electrocardiographic assessment following operative repair of tetralogy of Fallot. *Circulation* **58** (suppl I): 209, 1978
 15. Katz NM, Blackstone EH, Kirklin JW, Pacifico AD, Barger LM Jr: Late survival and symptoms after repair of tetralogy of Fallot. *Circulation* **65**: 403, 1982
 16. 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* **54**: 671, 1976