Long-term Prognostic Assessment of Ventricular Tachycardia with Respect to Sudden Death in Patients with and without Overt Heart Disease

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The purpose of this study is to investigate the long-term prognosis of ventricular tachycardia (VT) mainly with respect to sudden death (SCD) in patients with ischemic heart disease (IHD), idiopathic cardiomyopathy (ICM), miscellaneous heart disease (MHD) and idiopathic ventricular tachycardia (IVT).

The study included 117 patients with VT (80 male, 37 female). The number of patients with IHD, ICM, MHD and IVT were 40, 18, 26 and 33, respectively. Follow-up was conducted by means of a mailed standardized questionnaire. The mean follow-up period was 46.8 ± 32.0 months (range from 6 to 125 months).

In 24 out of the 117 patients the cause of death was SCD, in 9 there was no sudden cardiac death and in 5 no cardiac death. The other 76 were surviving. The number of SCD in IHD, ICM, MHD and IVT was 14/40 (35%), 4/17 (24%), 6/25 (24%) and zero (0%), respectively. The number having had syncope in IHD, ICM, MHD and IVT was 19/40 (48%), 7/18 (39%), 6/26 (23%) and 6/33 (18%), respectively. Out of the 19 IHD patients with syncope, 15 had had ventricular fibrillation (VF). As for IVT with syncope, only one of the 6 had VF, which was induced by a disopyramide injection.

In IVT, the patients with syncope had a significantly higher VT rate than those without syncope ($p < 0.01$). There were no significant differences in the electrocardiographical high risk parameters for SCD, the age, follow-up periods, the presence or absence of VF and ejection fraction between the SCD and the surviving groups. Consequently, it is suggested that IVT is not related to SCD but careful attention should be paid to syncope when the rapid VT rate is observed although VT with organic heart disease is closely related both to SCD and syncope. In addition, it is considered that the above electrocardiographical parameters and so on were not always independent predictors of SCD among the patients having VT.

VENTRICULAR tachycardia (VT) has been known as one of the serious arrhythmias and occur not only in patients with organic heart disease but also with no apparent heart disease, idiopathic VT (IVT).

In general, although the presence of VT in

patients with organic heart disease, especially with previous myocardial infarction, has been shown to be associated with subsequent sudden cardiac death (SCD)¹⁻⁶. However, concerning the long-term prognosis of the patients with IVT. There have been very few studies, being limited and sparsely reported^{7,8}.

The purpose of this report is to provide such a information and to compare the long-term prognosis of IVT patients to that of VT patients with organic heart disease mainly with respect to SCD. Additionally, a comparison of the value

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TABLE 1 SUBJECTS

Underlying disease	Nos. of male	Nos. of female	Total	Age (mean $\pm$ SD) y.o.
Ischemic Heart Disease (IHD)	30	10	40	38–87 (62.8 $\pm$ 12.8)
Idiopathic Cardiomyopathy (ICM)	13	5	18	22–70 (49.4 $\pm$ 15.3)
Miscellaneous Heart Disease (MHD)	16	10	26	30–87 (62.9 $\pm$ 16.2)
Idiopathic Ventricular Tachycardia (IVT)	21	12	33	20–73 (46.0 $\pm$ 12.9)
Total	80	37	117	20–87 (56.1 $\pm$ 16.1)

TABLE II LONG-TERM PROGNOSIS OF PATIENTS WITH VENTRICULAR TACHYCARDIA (VT)

of electrocardiographical high risk parameters for SCD was made between the groups of SCD and survivors.

SUBJECTS AND METHODS

Study Patients

The study population consisted of 117 patients with VT who had been admitted to Tokai University Hospital between September 1976 and December 1987. All of them had one or more VTs (runs of more than three consecutive ventricular premature contractions at a minimum rate of 120 bpm) per day in the recordings obtained from Holter monitoring during the hospitalization.

Their ages ranged from 20 to 87 years (m $\pm$ SD, 56.1 $\pm$ 16.1). Forty of the 117 patients had previous myocardial infarctions or angina pectoris with coronary stenosis (IHD), 18 had idiopathic cardiomyopathy (ICM), 26 had miscellaneous heart disease (MHD) and 33 had IVT (Table I). Patients with acute or recent myocardial infarctions, unstable angina, deteriorating

congestive heart failure, advanced atrioventricular block, electrolyte imbalance, hypoxia or digitalis intoxications were excluded because such unstable heart conditions were not suitable for the purpose of this study.

Follow-up Methods

Follow-up was conducted by means of a mailed standardized questionnaire. If the reports returned showed death or no reply received, one of us (T.T.) conducted a direct telephone interview with the study subject or family members. Particular care was taken to document SCD or non-sudden death. SCD was defined as a witnessed death occurring within 1 hour of the onset of acute symptoms.

The above questionnaires were sent during December 1987. The mean follow-up period from the detection of VT during the hospitalization was 46.8 $\pm$ 32.0 months (range 6 to 125 months). When there was documented acute myocardial infarction and subsequent sudden death within 7 days and the cause of death was associated with ventricular tachycardia, such

Fig.1. Comparison of the incidence of cases of deaths among ischemic heart disease (IHD), idiopathic cardiomyopathy (ICM), miscellaneous heart disease (MHD) and idiopathic ventricular tachycardia (IVT). Shaded areas inside the bar graph reflect the incidence of sudden cardiac death. *stomach CA; stomach cancer.

death was not classified as SCD for the purpose of this study.

Recordings and Analysis of Holter ECGs

A Del Mar-Avionics Electrocardiocorder 447 was used for Holter monitorings. Each tape was analyzed using a Del Mar-Avionics Dynamic Electrocardioscanner DCG VII and a Fukuda-Denshi-Co. Sigmacorder, which could print out a 24-hour ECG monitoring in 12 min.

The maximum consecutive VPCs (VT max) was detected from the recording of a sigmacorder and measurements were made on the VT max. These measurements included: (1) the normal RR cycle length preceding the VT max (RR), (2) the QT interval of the preceding cycle of VT max, and (3) the coupling interval (CI) of ventricular premature beat initiating VT max.

Prematurity and vulnerability indices were calculated for VT max. The prematurity index (PI) of VT max was defined as the CI of that beat normalized by the QT interval of the preceding beat (CI/QT). The vulnerability index (VI) as defined by Han and Goel⁹ was obtained by multiplying the reciprocal of the PI by the duration of the preceding cycle (RR/PI).

Measurements of Electrocardiographical Risk Parameters

Electrocardiographical risk parameters for SCD included CI, PI, VI, QTc (QT/RR), VT rate (ventricular frequency per minute in the VT max) and the grading score of VT. The grading score of VT meant severity of VT and was determined from the VT max. It was defined

as follows:

- grade 1; 3 to 5 consecutive VPCs
- grade 2; 6 to 9 consecutive VPCs
- grade 3; 10 to 19 consecutive VPCs
- grade 4; more than 20 consecutive VPCs
- grade 5; sustained VT (continuing more than 30 seconds)
- grade 6; changes from VT to ventricular fibrillation (VF)

The above electrocardiographical parameters, age, follow-up periods, confirmation of VF, history of syncope and ejection fraction (EF) by radionuclide ventriculography (RI angiography) were compared between the subjects with SCD and non SCD groups. In addition, concerning the syncope, the VT rates were compared between the groups with and without syncope.

RESULTS

Table II shows the long-term prognosis of patients with VT. Of the 117 VT patients, three responded to neither the questionnaire nor the telephone call. Of the 114 who responded, 76 patients were surviving and 38 had died, 5 of non-cardiac causes. The cause of death in the other 33 was judged to be cardiac. Twenty four of the 33 were identified as SCD and the remaining 9 as non-sudden cardiac death. The cause of death in the latter 9 was aggravating congestive heart failure in 6, acute MI in 2 and dissecting aneurysm in 1.

Figure 1 shows the comparison of the incidence of cases of deaths among IHD, ICM, MHD and IVT groups. Shaded areas inside the bar

Fig.2. Comparison of the incidence of cases with a symptom of syncope among ischemic heart disease (IHD), idiopathic cardiomyopathy (ICM), miscellaneous heart disease (MHD) and idiopathic ventricular tachycardia (IVT). Shaded areas inside the bar graph reflect the incidence of cases with confirmation of VF.

Fig.3. Comparison of the mean VT rates ($m \pm SE$) between the patients with and without syncope in ischemic heart disease (IHD), idiopathic cardiomyopathy (ICM), miscellaneous heart disease (MHD) and idiopathic ventricular tachycardia (IVT).

graph reflect the incidence of SCD. No cardiac deaths were observed in the IVT although 1 patient died of stomach cancer. The incidence

of SCD in IVT was significantly lower than that in IHD or ICM or MHD ($p < 0.01$). However, there were no significant differences in the inci-

TABLE III COMPARISON OF THE VALUES OF ELECTROCARDIOGRAPHICAL RISK PARAMETERS FOR SUDDEN CARDIAC DEATH (SCD) BETWEEN THE PATIENTS WITH SCD AND SURVIVING GROUPS IN ISCHEMIC HEART DISEASE (IHD), IDIOPATHIC CARDIOMYOPATHY (ICM) AND MISCELLANEOUS HEART DISEASE (MHD)

	Disease	SCD	Surviving	Significance
Coupling Interval (sec)	IHD	0.52 ± 0.14 (5)	0.54 ± 0.29 (10)	NS
	ICM	0.45 ± 0.02 (4)	0.47 ± 0.11 (7)	NS
	MHD	0.57 ± 0.09 (6)	0.58 ± 0.17 (9)	NS
Prematurity Index	IHD	1.10 ± 0.32 (11)	1.31 ± 0.40 (15)	NS
	ICM	1.46 ± 0.30 (4)	1.33 ± 0.16 (10)	NS
	MHD	1.33 ± 0.31 (6)	1.47 ± 0.29 (9)	NS
Vulnerability Index	IHD	0.83 ± 0.42 (3)	0.64 ± 0.38 (14)	NS
	ICM	0.59 ± 0.17 (4)	0.45 ± 0.11 (8)	NS
	MHD	0.71 ± 0.27 (6)	0.70 ± 0.32 (9)	NS
QTc	IHD	0.45 ± 0.07 (13)	0.44 ± 0.03 (14)	NS
	ICM	0.43 ± 0 (4)	0.44 ± 0.04 (8)	NS
	MHD	0.50 ± 0.10 (6)	0.46 ± 0.03 (9)	NS
VT rate (sec)	IHD	0.36 ± 0.08 (14)	0.38 ± 0.12 (16)	NS
	ICM	0.41 ± 0.03 (4)	0.42 ± 0.09 (9)	NS
	MHD	0.42 ± 0.07 (6)	0.39 ± 0.08 (13)	NS
*Grading Score of VT	IHD	2.7 ± 1.8 (14)	2.7 ± 2.1 (20)	NS
	ICM	2.8 ± 1.5 (4)	1.3 ± 0.7 (11)	NS
	MHD	2.7 ± 2.3 (6)	2.0 ± 1.8 (14)	NS

*Grading Score of VT -----Severity of VT () = n
 3 to 5 consecutive VPCs --- 1, more than 20 consecutive VPCs --- 4
 6 to 9 consecutive VPCs --- 2, sustained VT (more than 30 sec) --- 5
 10 to 19 consecutive VPCs --- 3, VT → VF --- 6

dence of total deaths or SCD among IHD, ICM and MHD groups.

Figure 2 shows the comparison of the incidence of cases having had a symptom of syncope among IHD, ICM, MHD and IVT groups. Shaded areas inside the bar graph reflect the incidences of cases with experiences of VF which had been confirmed by electrocardiograms recorded during the hospitalization. The incidence of syncope in IHD was significantly higher than that of MHD ($p < 0.05$) or IVT ($p < 0.01$). The incidence of VF in patients with syncope was lower in IVT than in IHD ($p < 0.01$) or ICM ($p < 0.05$). Out of 33 patients with IVT, 6 had a history of syncope. One of the 6 had confirmation of VF. However, the VF did not spontaneously occur, but was induced by the intravenous injection of 50 mg disopyramide whose administration was slowly performed to stop sustained VT.

Figure 3 shows the comparison of the mean

VT rates ($m \pm SE$) between the patients with and without syncope in IHD, ICM, MHD and IVT groups. A significant difference was observed in the VT rate of IVT between the syncope and the non-syncope groups ($p < 0.01$), while no significant differences were seen in that of IHD, ICM and MHD between the 2 groups.

Table III shows the comparison of the value of electrocardiographical risk parameters in IHD, ICM and MHD between SCD and surviving groups. No significant differences were observed in any parameters of CI, PI, VI, QTc, VT rate and the grading score of VT between the 2 groups. However, the grading score of VT in the SCD group tended to be higher than that in surviving group in ICM and MHD, while such tendencies were not observed in IHD.

Table IV shows the comparison of age, follow-up periods, cases with confirmation of VF and EF by the RI angiography between SCD and

TABLE IV COMPARISON OF AGE, FOLLOW-UP PERIODS, PRESENCE OR ABSENCE OF DOCUMENTATION OF VENTRICULAR FIBRILLATION (VF) AND EJECTION FRACTION (EF) BETWEEN THE SUDDEN CARDIAC DEATH (SCD) AND SURVIVING GROUPS

	Disease	SCD	Surviving	Significance
Age (y.o.)	IHD	60.7 ± 10.8 (n = 14)	62.1 ± 14.5 (n = 20)	NS
	ICM	39.5 ± 14.9 (n = 4)	50.5 ± 16.5 (n = 11)	NS
	MHD	68.5 ± 9.7 (n = 6)	56.4 ± 17.5 (n = 14)	NS
Follow-up periods from detection of VT (months)	IHD	69.5 ± 35.5 (n = 14)	50.6 ± 30.8 (n = 20)	NS
	ICM	30.3 ± 19.6 (n = 4)	29.8 ± 18.3 (n = 11)	NS
	MHD	53.7 ± 42.3 (n = 6)	38.3 ± 30.5 (n = 14)	NS
Confirmation of VF in the past	IHD	6 / 14	7 / 20	NS
	ICM	2 / 4	4 / 8	NS
	MHD	1 / 6	2 / 14	NS
EF by RI Angiography (%)	IHD	34.8 ± 19.2 (n = 8)	44.3 ± 13.4 (n = 10)	NS
	ICM	19.5 ± 6.8 (n = 4)	35.4 ± 20.6 (n = 6)	NS
	MHD	50.3 ± 10.5 (n = 6)	52.1 ± 11.6 (n = 8)	NS

surviving groups. There were no significant differences in the above factors between the 2 groups. However, EF in the SCD group tended to be lower than that in the surviving group in IHD or ICM.

DISCUSSION

Many papers have identified VT as an independent risk factor for subsequent SCD at a long-term follow-up in patients with myocardial infarction.³⁻⁵ Bigger et al⁴ identified VT (3 or more complexes) on 11.6% of the predischARGE ambulatory ECG recordings in the postinfarction period and found a one-year cardiac mortality rate of 38% associated with the finding, as compared to 11.6% in those without this finding. According to the report of the Multicenter Post-infarction Group,⁵ the 2-year incidence of SCD was 17% in patients with VT, as compared to 3% in patients without VT. On the other hand, Moeller et al¹⁰ and Anderson et al¹¹ did not find VT to be statistically associated with SCD after infarction.

In the present study, 14 out of the 40 patients (35%) with previous myocardial infarctions were identified to be in the SCD group in about a 4-year follow-up period.

Concerning the prognostic significance of VT in patients with other kinds of underlying diseases, details with respect to SCD remained undefined. In particular, the long-term prognosis

of patients with IVT has been unknown in detail. However, there are some papers on the long-term prognosis of patients with ventricular ectopy which is considered to be the fundamental form of ventricular arrhythmias.

Kennedy et al¹² showed that subjects with frequent and complex ventricular ectopy who are asymptomatic and considered apparently healthy on the basis of non-invasive cardiologic evaluation have a relatively good long-term prognosis after diagnosis. That is, 2 of 73 study patients died during the follow-up period of 6.5 ± 1.8 years (m ± SD) when as many as 7 deaths might have been predicted on the basis of the US death rates matched for age, sex and race.

Montague et al⁸ surveyed 45 younger subjects (mean age 25 years) with frequent ventricular ectopy with no underlying disease for a mean follow-up period of 22 months. Forty-three of the 45 had a good prognostic course, but one 16-week old subject with a family history of sudden infarct death syndrome was found dead in her crib and the other subject of a 36-year-old woman was confirmed to have symptomatic sustained VT later.

Other observations also support these good results of no underlying disease with ventricular premature ectopy.^{7,13}

In our study, out of 32 patients with IVT who responded to a questionnaire, no SCD patients were observed while SCD occurred in 14 of the 40 patients with IHD, in 4 of the 17

with ICM and 6 of the 25 with MHD.

This indicates that IVT has a favorable long-term prognosis with respect to SCD as well as ventricular ectopy.

Another serious problem associated with VT is cardiac syncope, which is called an Adams-Stokes attack and may be associated with subsequent SCD. Johansson¹⁴ reported that 8 out of the 16 patients with syncope, having electrocardiograms recorded during the attacks, showed ventricular tachyarrhythmias. Parkinson et al¹⁵ summarized electrocardiographical findings during the unconsciousness of a Stokes-Adams attack in 8 patients at their hospital and 56 other reported cases. As a result, out of a total of 64 patients, 4 showed VT followed by ventricular standstill; 15 showed high VT (high VT means a rate between 200–500), usually also with VF followed by ventricular standstill; 13 showed high VT, or VF, or both, without ventricular standstill and the remaining 32 showed ventricular standstill alone or extreme bradycardia with complete heart block.

These observations indicate that VT is extremely important as a cause of syncope. However, no prior studies have related the occurrence of syncope in relation to organic compared to non-organic heart disease. In the present study, the incidence of syncope in IHD was significantly higher than that in MHD or IVT.

The direct cause of syncope in patients with IHD was considered to be VF because most IHD patients had experienced VF (78.4%).

On the other hand, one of the 6 cases with syncope in IVT had experienced VF (16.7%). The VF of that case did not occur spontaneously, but was induced by a disopyramide injection. Therefore, it is likely that the direct cause of syncope in IVT is different from that in IHD. The patients with syncope in IVT had significantly higher VT rates than those without syncope. This suggests that syncope in IVT is caused by too low a cardiac output caused by rapid ventricular activity. However, this study did not determine why such a IVT does not develop into VF and SCD.

There were no significant differences in the value of CI, PI, VI, QTc, VT rate and the grading score of VT between the groups with and without SCD in this study. In addition, there were no significant differences in age, follow-up periods, the presence or absence of documentation of VF and ejection fraction between the 2 groups.

These parameters have been reported as some of the predictors for SCD in studies comparing patients with and without VT or comparing patients with ventricular premature beats and those with VT.^{3,16,17} As a result aggravated values were reported in patients with VT. However, this study was restricted to patients having had VT and the parameters were compared between the SCD and surviving groups. As a result, the above parameters were not always independent predictors of SCD among the patients having had VT.

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