CHARACTERISTICS OF NON-SUSTAINED VENTRICULAR TACHYCARDIA DETECTED BY AMBULATORY ELECTROCARDIOGRAPHY

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We analyzed non-sustained ventricular tachycardia (VT) observed during ambulatory electrocardiographic (ECG) monitoring in 21 subjects. The rate of VT was 160.7 ± 2.3 beats/min and showed a moderate positive correlation (r = 0.61, p < 0.01) with the preceding heart rate (81.8 ± 1.0 beats/min). The prematurity index of VT was 1.118 ± 0.015 and showed a moderate inverse correlation with the rate of VT (r = -0.64, p < 0.01). The vulnerability index was 0.713 ± 0.009. These indices of prematurity showed a wide distribution and the prematurity of ventricular ectopic beats may not be so significant as previously documented.

The incidence of VT was higher in the morning and the evening and was reduced by sleep. The most frequent type of VT (25—/day) was observed only in patients with VT predominantly occurring during the day. We have therefore postulated that these diurnal variations in the frequency of VT may have important therapeutic and prognostic implications. In this study, we used the classification of VT based on the focus, the diurnal variation and the frequency of the tachycardia. Ambulatory ECG monitoring is useful in distinguishing the various types of VT and it is important to separate the various types of VT into several subgroups in order to classify grade the severity of VT.

Ventricular tachycardia (VT) is thought to be a life threatening arrhythmia because of its rapid deterioration into ventricular fibrillation (VF) and subsequent sudden cardiac death. However, episodes of VT are usually self-limiting and asymptomatic in many reports of ambulatory electrocardiographic (ECG) recordings. In these reports, the majority episodes of VT were initiated by late coupled premature ventricular contractions (PVCs) and may not be likely to degenerate into VF.

Key Words:
Ventricular tachycardia
Life-threatening arrhythmia
Ambulatory electrocardiography
Prematurity
Diurnal variation

Other reports have shown PVCs interrupting the T waves (R on T phenomenon) and initiating VT or VF. However, these reports also show a large number of cases where the R on T phenomenon occurred without these serious arrhythmias being produced. In this study, we examined which characteristics correlated with the occurrence of VT and the diurnal variation of the VT episode.

SUBJECTS AND METHODS

Twenty-one patients, 12 men and 9 women, aged from 28 to 86 years were studied. Each patient had at least one ambulatory ECG record containing episodes of VT. VT was defined as three or more consecutive beats of ventricular
origin. The underlying heart disease was ischemic heart disease in seven patients, idiopathic cardiomyopathy in four patients, sick sinus syndrome and postoperative state of ventricular septal defect in one patient respectively. The other eight patients had no organic heart disease but four patients had hypertension and two patients had diabetes mellitus.

The ambulatory ECG was recorded in each of the 21 patients using a double-channel (a modified V₅ and V₁ lead system) 24-hour portable ECG tape recorder (Avionics Model 445). Patients carried out their normal daily routines and recorded diaries of their activities.

Each tape was scanned at high speed (× 120) using an Avionics 660A computerized electrocardioscanner and direct-writing samples were made of all the episodes of VT by automatic or manual analysis. For all the episodes of VT, the following values were measured by manual analysis of the rhythm strips: the consecutive number and average rate of the episode, heart rate prior to the episode, the R-R interval (R-R) immediately before the episode, the coupling

**TABLE I CLINICAL CHARACTERISTICS OF VT (SINGLE FOCUS v.s. MULTIFOCUS)**

<table>
<thead>
<tr>
<th></th>
<th>Single focus</th>
<th>Multifocus</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of patients</strong></td>
<td>18</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>59.0 ± 2.9</td>
<td>77.6 ± 2.4</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td><strong>Sex (Male : Female)</strong></td>
<td>10 : 8</td>
<td>2 : 1</td>
<td></td>
</tr>
<tr>
<td><strong>Time of VT occurred</strong></td>
<td>Day &gt; Night</td>
<td>Day &lt; Night</td>
<td></td>
</tr>
<tr>
<td><strong>Heart rate prior to VT</strong></td>
<td>71.7 ± 3.4</td>
<td>77.6 ± 2.4</td>
<td>N.S.</td>
</tr>
<tr>
<td><strong>Rate of VT</strong></td>
<td>147.7 ± 7.8</td>
<td>135.5 ± 17.3</td>
<td>N.S.</td>
</tr>
<tr>
<td><strong>Number of episodes of VT</strong></td>
<td>20.2 ± 9.9</td>
<td>9.0 ± 1.7</td>
<td>N.S.</td>
</tr>
<tr>
<td><strong>Prematurity index</strong></td>
<td>1.476 ± 0.088</td>
<td>0.994 ± 0.072</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td><strong>Vulnerability index</strong></td>
<td>0.626 ± 0.036</td>
<td>0.769 ± 0.046</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

N.S.: not significant

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interval (R-R') of the episode, the Q-T interval (QT) of the preceding sinus rhythm. The prematurity index of the initiating beat of VT was defined as (R-R')/QT and the vulnerability index as (R-R) x QT/(R-R').

The type of VT was classified by the following definition according to the classification of PVCs by Yanaga et al.11

Day type: the number of the episodes for the waking period (6 am - 9 pm) was more than 70% of that during the 24-hour period.

Night type: the number of VT episodes for the sleeping period (9 pm - 6 am) was more than 70% of that during the 24-hour period.

Mixed type: types other than the day type or the night type.

RESULTS

1. Electrocardiographic Features of VT

1) Number of VT episodes

In a total of 504 hours of ambulatory ECG monitoring, 391 episodes of VT were observed from 21 patients. The consecutive number of beats of each episode ranged from 3 to 47 beats [3 beats duration in 204 (52%) of the episodes, 4 beats duration in 81 (21%), 5 beats duration in 57 (15%), 6-47 beats duration in 49 (12%)]. The VT terminated spontaneously in all cases with no episodes degenerating into Vf.

2) Rate of VT

The rate of VT was 160.7 ± 2.3 (mean ± standard error) beats/min (range 82 to 220) and showed a moderate positive correlation with the preceding heart rate (r = 0.61, p < 0.01). The mean heart rate before the episode of VT was 81.8 ± 1.0 beats/min (range 50 to 121), and the majority of episodes were observed at a normal heart rate (11% at sinus bradycardia, 76% at ordinary sinus rhythm, 13% at sinus tachycardia).

3) Irregularity in cycle length of VT (Fig. 1)

The difference of the R-R interval of VT in all cases was 0.066 ± 0.004 sec and 78% of that showed a variation within 0.08 sec. The mean value of the difference in cycle length of multifocal VT was 0.138 ± 0.028 sec and was significantly greater than that (0.059 ± 0.004 sec) of unifocal VT (p < 0.001).

4) Focus of VT (Table I)

Although the rate and consecutive number of the tachycardia did not reach statistical significance between multifocal and unifocal VT, the mean age (77.6 ± 2.4 years) of patients with multifocal VT was significantly older than that (59.0 ± 2.9 years) of patients with unifocal VT (p < 0.05).

The prematurity index (0.994 ± 0.072) in patients with multifocal VT was significantly smaller than that (1.476 ± 0.088) in patients.
with unifocal VT (p < 0.05), but the vulnerability index did not reach statistical significance between both subgroups.

2. Onset of the Episode of VT

The prematurity index of the first extrasystoles of each episode of VT was 1.118 ± 0.015 (range 0.7 to 2.0) and showed a moderate inverse correlation with the rate of VT (r = -0.64, p < 0.01). The majority of episodes of VT (58%) occurred when the prematurity index was greater than 1.0, and only 21 of the episodes (54%) occurred at a prematurity index of 0.6 to 0.85 when Vf was likely to occur.12

The vulnerability index expressed as the ratio of the product of the basic QT interval and the preceding cycle length to the coupling interval was 0.713 ± 0.009 (range 0.3 to 1.3). All but 5 episodes (98.7%) had a vulnerability index less than 1.1 and no episodes occurred at a vulnerability index over 1.4 when Vf was likely to occur.5

3. Diurnal Variation and Incidence of the VT

1) Diurnal variation of VT

The number of the episodes of VT throughout the 24 hours in all the subjects is shown in Fig. 2. The incidence of VT exhibited two peaks at 7 am and 4 pm. The total number of the episodes during sleep was reduced by about 75% as compared to that observed during waking hours.

In the present study, we classified the VT episodes into the day type, the night type and the mixed type according the diurnal variation using ambulatory ECG monitoring. The number of patients with each type of VT was, respectivele, 13 cases (62%), 7 cases (33%) and 1 cases (50%). The mean frequency of the episodes was 26.8 ± 13.4 times/day for the day type and 5.6 ± 2.1 times/day in for the night type. Although there was no statistically significant difference in the frequency of VT between the day and night types, the most frequent VT (25–/day) was observed only in the patients with episodes of the day type.

2) Incidence of VT episode (Table II)

The total numbers of the episode per patient over 24 hours ranged from 1 to 165. According to the frequency of the episode, the VT was classified into three types; single type (1/day), sporadic type (2–24/day) an frequent type (25–/day). The number of patients with each type of
VT was, respectively, 9 cases (43%), 8 cases (38%) and 4 cases (19%). The underlying heart disease of the patient with each type of VT is presented in Table III. There was no statistically significant difference in the prevalence of organic heart disease between each group.

Although the mean rate of VT in patients with frequent episodes tended to be higher (168.7 ± 18.5 beats/min) as compared with that (139.8 ± 7.0 beats/min) in patients with single episode, this did not reach statistical significance (p < 0.1). Furthermore, the vulnerability index of VT in patients with frequent or sporadic episodes tended to be higher as compared with those in patients with single episode (p < 0.1), but there was no significant difference in the prematurity index between these three types of VT.

**DISCUSSION**

This study presents the electrocardiographic features of the VT episode in the first part. In the recent studies on the electrocardiographic details of VT using an ambulatory ECG monitoring2–6 VT in ambulatory subjects was consisted of infrequent, self-limiting episodes and most episodes of VT were not initiated by the R on T phenomenon. The VT observed in this study had also these electrocardiographic features.

VT usually leads to a regular rhythm. In the present study, the difference in cycle length of the VT showed a wide distribution but 78% of that exhibited a variation within 0.08 sec. The mean value of the difference of multifocal VT was significantly greater than that of unifocal VT. The prematurity index in patients with multifocal VT was also significantly smaller than that in patients with unifocal VT. Thus, multifocal VT may indicate more ventricular irritability.

Early studies of the electrophysiology of the heart showed that electrical stimulation during the vulnerable phase of ventricular repolarization is likely to produce tachycardia or fibrillation.13–15 In contrast, many recent studies have noted that late-coupled PVCs also causes VT or VF and that the R on T phenomenon occur without the tachyarrhythmia being produced.2–10 In an experimental study recording epicardial electrograms of acute ischemia in dog, Williams et al.16 indicated that the major determinant of malignant ventricular arrhythmias in acute ischemia may be the related abnormalities of ventricular activation rather than the coupling of the PVCs. Although many episode of VT were induced by late-coupled PVCs in this study, the prematurity index of VT showed a wide distribution. Thus, prematurity of ventricular ectopic beats may not be so significant as previously documented13–15 consistent with the opinion of Winkle et al.7

Yusuf et al.7 have reported that a significant inverse correlation exists between the rate and the prematurity index of VT and that patients developing VF from preceding VT show faster rates of VT and shorter prematurity indices than patients without VF. The prematurity index of VT observed in this study also showed a inverse correlation with the rate of VT. Furthermore, in the patients with frequent episodes, the rate of VT tended to be faster and the vulnerability index of VT tended to be larger compared with those in the patients with single episode. Thus, the incidence of VT may influence the severity of VT. However, the prevalence of organic heart disease was not significantly different among the patients with each frequency of VT.

In the present study, we have demonstrated circadian variation in the frequency of VT in ambulatory patients. The incidence of VT was higher in the morning and the evening, and was reduced during sleep. Balasubramanian et al.18 postulated that a marked increase in blood pressure (BP) occurring in the morning may be related to the increased incidence of stroke and myocardial infarction about that time in the morning. They also hypothesized that the early morning increase in BP may be the result of intense sympathetic activity mediated by α-adrenoceptors. The pattern changes of the diurnal variation of VT observed in this study corresponded to their observation in BP.

Lown et al.19 studied the effect of sleep on PVCs in ambulatory patients and concluded that treatment of sporadically occurring ventricular ectopic activity in some patients may require attention to the neurophysiologic trigger rather than the cardiac target. The incidence of VT in the present study was also reduced during sleep and the reduction of the episode may be related to lesserened sympathetic tone as mentioned by Lown et al. Furthermore the frequent type of VT was observed only in patients whose episodes of VT predominantly occurred during the day time. We have therefore postulated that these diurnal variations in the frequency of VT may have important therapeutic and prognostic impli-
We have shown the characteristics of non-sustained VT observed in ambulatory patients. Although the prematurity index of the tachycardia showed a wide distribution, the episode in patients with multifocal VT had a lower prematurity index and there was a problem about the mixture of these various types of VT into a single "VT group". Ambulatory ECG monitoring is useful in distinguishing the various types of VT and it is important to separate the various types of VT into several subgroups in order to classify the severity of VT.

REFERENCES