Characteristics of Ventricular Ectopic Beats in Patients with Ventricular Tachycardia

A 24-Hour Holter Monitor Study


A total of 99 consecutive 24-hour Holter recordings with ventricular tachycardia were reviewed. Ventricular premature beats which occurred alone, and ventricular premature beats which initiated ventricular tachycardia were examined to determine which characteristics correlated with occurrence of ventricular tachycardia and which predicted rate and duration of ventricular tachycardia. The preceding R-R interval, the coupling interval, and a ratio of the two were examined. We found that ventricular tachycardia rate and duration increase with a shorter coupling interval, and the coupling interval/preceding R-R ratio was significantly different in single beats not initiating ventricular tachycardia. The ratio for the beat initiating ventricular tachycardia was smaller, indicating more prematurity.

Ventricular ectopic activity, including ventricular premature beats and ventricular tachycardia have been associated with an increased mortality. It has been suggested that certain characteristics of ventricular premature beats may be identified which may predict the occurrence of ventricular tachycardia or its rate and duration. These characteristics include underlying heart rate and prematurity. This study examines the 24-hour Holter recordings of 99 patients with episodes of ventricular tachycardia. Ventricular premature beats which occurred alone, and ventricular premature beats which initiated ventricular tachycardia were examined to determine which characteristics correlated with occurrence of ventricular tachycardia and which predicted rate and duration of ventricular tachycardia.

Materials and Methods

A total of 99 consecutive 24-hour Holter recordings with ventricular tachycardia were examined. Ventricular tachycardia was defined as four or more successive beats of ventricular origin. A typical example of ventricular tachycardia is shown in Figure 1.

There were 63 male and 36 female subjects with a mean age of 66 ± 15 years. The Holter recordings were done because of symptoms of dizziness in 46, palpitations in 30, chest pain in 20, and routine postmyocardial infarction in 3. None of the patients had acute myocardial infarction.

In order to study characteristics of the ventricular beat initiating ventricular tachycardia, the following measurements were taken: the preceding R-R interval, the coupling interval, and a ratio of the two were examined. The first beat of the preceding R-R interval may have been a sinus beat or a ventricular premature beat. Figure 2 illustrates why we chose to use these simple measurements rather than the more commonly used QT interval. In this recording, as in many others, we found it difficult to accurately measure QT interval. On the other hand, the preceding R-R interval and the coupling interval were measurements that we felt we could do with little error. In addition, we also calculated the QT interval of the last supraventricular beat. This was done using the preceding R-R interval and using the formula: QT = .2 + .2 (R-R). Many short episodes of ventricular tachycardia were slightly irregular. In these instances, we measured the R-R intervals and took an average in order to calculate the rate of ventricular tachycardia. The following formula was used to indicate prematurity: coupling interval/R-R = prematurity.

The 24-hour ECGs were recorded on two-channel electro-recorders and analyzed on an electroscanner. This was a high speed playback system that permits analysis at 60 or 120 times real time. The electroscanner was supplemented by the arrhythmia analyzer permitting hourly quantification of premature beats. The electrode placement was selected to obtain a left epicardial lead (V6) and a second lead of different configuration to best demonstrate optimal variant ventricular premature beat configuration.

Ventricular premature beats which did not initiate ventricular tachycardia but which had a morphologic condition similar to the ventricular tachycardia were also studied. In order for these beats to be considered similar to the ventricular tachycardia, they had to have an identical appearance in
The mean number of beats of each episode was 9.5 ± 10.6 beats and ranged from 4 to 65 beats (Fig 4).

The relationship of the preceding R-R interval with rate and duration of ventricular tachycardia was 141 ± 26 beats per minute and ranged from 80 to 230 beats per minute (Fig 3). The mean number of beats of each episode was 9.5 ± 10.6 beats and ranged from 4 to 64 beats (Fig 4).
The relationship of the preceding R-R interval with rate and duration of ventricular tachycardia was $-0.104$ and $-0.142$, respectively. These negative correlations indicate that as the preceding R-R interval gets smaller, the rate and duration of the ventricular tachycardia increases. This trend, however, was not statistically significant. Three of the 99 patients (3 percent) had episodes of ventricular tachycardia initiated by an "R on T" beat. This was determined by calculated QT interval and not by visual inspection. These three episodes of ventricular tachycardia had a rate of 230, 200, and 180 beats per minute and a duration of 61, 71, and 7 beats, respectively. The relationship between the coupling interval and ventricular tachycardia rate and duration is shown in Table 1. Again, a negative correlation exists indicating that as the coupling interval decreased, the duration and rate of ventricular tachycardia increased. This was significant at the levels noted.

Table 1 also shows the relationship between the coupling interval/preceding R-R ratio and the variables of ventricular tachycardia rate and duration. The negative correlation indicates that as the ratio got smaller the rate and duration of tachycardia increased.

A total of 71 of the 99 patients had ventricular premature beats with morphologic findings similar to ventricular tachycardia. Figure 5 illustrates a typical example. The preceding R-R interval, the coupling interval, and the ratio of the two were examined both for the beat initiating ventricular tachycardia and the single beat not initiating ventricular tachycardia. The first 100 ventricular premature beats were measured and following this, every tenth beat was measured. When the prematurity index of the ventricular premature beats varied, we chose to use the smallest ratio. We chose this method since we felt that if any bias was introduced, this bias would not favor the hypothesis we were testing, that the beat initiating ventricular tachycardia was more premature than the beat not initiating ventricular tachycardia. The difference between the two sets was $-0.073$. Using a paired $t$-test, the $t$ equalled $-1.99$, which reached a level of significance of $P = 0.05$. This analysis indicated that the ratio of preceding R-R interval to coupling interval was less in the beat initiating ventricular tachycardia. Eight of the intervals were exactly the same, but the remainder all varied. When these were all averaged together, the difference was approximately 9 percent and did reach a level which was statistically significant.

**DISCUSSION**

The dangers of an R wave of an ectopic beat falling on the T wave of the preceding beat ("R on T phenomenon") were described by Smirk and associated with a high prevalence of sudden death. This phenomenon might be explained by the presence of nonhomogeneous excitability of the ventricle during this phase of the cardiac cycle.

Many studies have shown R on T prior to and initiating ventricular tachycardia or ventricular fibrillation. However, these studies also show a significant number of instances where the R on T
phenomenon occurred without arrhythmias being produced. DeSoyza and co-workers\textsuperscript{12} studied patients with acute myocardial infarction. They found that 12 percent of episodes of ventricular tachycardia were initiated by R on T. Some 16 percent of ectopic beats in the same group showed R on T but did not initiate ventricular tachycardia. Winkle et al\textsuperscript{14} studied ambulatory tape recording and noted R on T in only 15 percent of episodes of ventricular tachycardia. Chou and Wenzke,\textsuperscript{19} Boudoulas\textsuperscript{20} and Kleiger et al\textsuperscript{15} have specifically noted late ventricular premature beats causing ventricular tachycardia and ventricular fibrillation. In ectopic beats with a long coupling interval, it is presumed that slowed conduction and unidirectional block, which are necessary for reentry, occur later in diastole.

A recent review of the "R on T phenomenon" by Engle et al\textsuperscript{21} concludes that recent observations cast doubt on the importance of a phase within the T wave especially vulnerable to induction of tachyarrhythmias by ectopic beats.

Our incidence of true R on T was only 3 percent. This may be explained by our patient population, which excluded patients with acute myocardial infarction. It may also be explained by our method of calculating the QT interval. There were an additional 11 patients with a coupling interval which was only 0.1 to 0.4 second longer than the QT interval. These were not included as R on T beats but might have been included in a series where the QT interval was measured visually.

There has been considerable interest in the relationship between underlying heart rate and ventricular arrhythmia. There appears to be evidence that extremes of both bradycardia and tachycardia increase ventricular arrhythmia.\textsuperscript{22} Bradycardia increases ectopia by increasing the dispersion of refractoriness,\textsuperscript{23} while tachycardia may increase non-homogeneity of refractory periods, and thus, increases the likelihood of ventricular fibrillation.\textsuperscript{24}

Winkle et al\textsuperscript{14} studied the relationship between underlying heart rate and rate of ventricular tachycardia. He found a modest positive correlation with the rate of the ventricular tachycardia increasing as the underlying heart rate increased. He postulated that this faster ventricular rate might diminish myocardial efficiency. This might increase the likelihood of ventricular fibrillation, especially if the increased underlying heart rate was caused by exercise and associated with increased catecholamines. We noted a similar trend, but it did not reach levels which were statistically significant. Rothfeld et al\textsuperscript{16} evaluated the relationship between coupling interval and malignant characteristics of ventricular tachycardia in a group of patients with myocardial infarction. He noted that episodes that were started by a short coupling interval or R on T lasted longer and more often progressed to ventricular fibrillation. We studied the relationship between coupling interval and both the duration and speed of ventricular tachycardia. We found that the rate of the ventricular tachycardia increased as the coupling interval decreased. This was statistically significant (P > 0.001) and probably is of clinical importance. A similar but less significant relationship was observed between coupling interval and duration of ventricular tachycardia.

Many of the Holter scans with episodes of ventricular tachycardia also have ventricular premature beats which do not initiate ventricular tachycardia. When these single ectopic beats have exactly the same morphologic findings as the ventricular tachycardia, it is intriguing to postulate why one precipitates tachycardia and the other does not. DeSoyza et al\textsuperscript{12} examined this relationship and did not find any significant difference between the mean
coupling interval of the ventricular premature beat initiating ventricular tachycardia and the coupling interval of the ventricular premature beat which did not initiate ventricular tachycardia. We examined 71 individual sets of ventricular tachycardia and beats not initiating ventricular tachycardia. Our analysis indicated that the ratio of preceding R-R interval to coupling interval was less in the beat initiating ventricular tachycardia. This increase in the amount of prematurity was approximately 9 percent and did reach a level which was statistically significant.

We conclude the following: (1) the coupling interval, and a ratio of the coupling interval and preceding RR interval, correlate with both ventricular tachycardia rate and duration. Ventricular tachycardia rate and duration increase with a shorter coupling interval; and (2) the coupling interval/preceding R-R ratio was significantly different in single beats not initiating ventricular tachycardia. The ratio for the beat initiating ventricular tachycardia was smaller, indicating more prematurity.

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