Comparison of 24 Versus 12 Hours of Ambulatory ECG Monitoring*

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In order to assess the additional information obtained from 24 hours compared to 12 hours of ambulatory ECG (electrocardiogram) recording, we analyzed 72 ambulatory ECG monitoring tapes in which arrhythmias were present. In all cases the second 12 hours included the entire period of sleep. Only 38 of 233 (16 percent) episodes of arrhythmias, frequent premature ventricular contractions (PVC's), two or more PVC's in a row, multiformal PVC's, ventricular bigeminy, trigeminy, premature atrial contractions (PAC's), and supraventricular tachyarrhythmias occurred for the first time in the second 12-hour period. New ventricular arrhythmias were detected during the second 12-hour period in 13 percent of the arrhythmic episodes. Although sleep resulted in a marked decrease in PVC frequency in 63 percent of 30 recordings, with frequent PVC's while awake, 8 percent had a significant increase during sleep. In contrast, short runs of supraventricular tachyarrhythmias occurred during the second 12 hours in 48 percent of cases, 66 percent of these while asleep. These data suggest that a 24-hour ambulatory ECG tape recording be utilized initially to characterize the occurrence and frequency of the patients' ambulatory arrhythmias during awake and sleep periods. Thereafter, additional ECG recordings for monitoring antiarrhythmic drug therapy can be accomplished with a 12-hour recording in more than 80 percent of patients.

In the past five years there has been an increasing interest in the use of ambulatory ECG monitoring.1 This technique has been applied to the detection and quantification of symptomatic or asymptomatic arrhythmias, to epidemiologic studies of patients with coronary artery disease, and to assessment of antiarrhythmic therapy efficacy.2-7 With the introduction of 24-hour ambulatory ECG recorders, the amount of data to be analyzed more than doubled compared to the 6 to 12 hours of ECG recording previously used.2,4 This is associated with increased expense in the processing and analysis of the ECG data collected; however, the advantage of 24 hours versus 10 or 12 hours of ECG recording has not been established.

This report summarizes the results of our evaluation of the number of new and serious arrhythmias detected only in the second 12 hours of a 24-hour ambulatory ECG recording.

**Material and Methods**

During a 7-month period, 242 ambulatory ECG monitorings were recorded at the Center for the Study of Sudden Death at Stanford University Medical School. We selected 72 of these 24-hour recordings done in 54 patients which showed serious arrhythmic abnormalities defined as at least one of the following: 1) frequent PVC's or 10 or more peak PVC's per 15 minutes; 2) two (pairs) or more (ventricular tachycardia) PVC's in a row; 3) multiformal PVC's; 4) ventricular bigeminy and/or trigeminy; and 5) three or more PAC's in a row (paroxysmal supraventricular tachyarrhythmias—SVT). In order to exclude sleep from the first 12 hours of recording, we selected only tapes starting before 10:00 A.M.

**Characteristics of the Patient Group**

Of the 54 patients, 45 were men and 9 were women, with an age range from 17 to 83 years (mean age 51 years). The patients were divided into four groups: Group 1—ten patients with proved coronary artery diseases (CAD) and receiving no medication except for nitroglycerin at the time of the recording; Group 2—four patients with proved CAD but receiving some form of medication (2 patients on propranolol, 1 patient on quinidine, and another on procainamide) Group 3—twenty patients with miscellaneous heart disease or no evidence of heart disease; receiving no medication; and Group 4—twenty patients with miscellaneous heart disease, but receiving cardiac medication.

**Ambulatory ECG Recording**

A single-channel portable recorder (Avionics) with the capability of recording 24 hours of ECG data was used. Prefiltered, disposable electrodes were applied at the level of the sternum after careful shaving and cleaning of the skin. A modified V1 lead was chosen which minimized noise associated with muscular movement, but provided adequate amplitude of the P wave and QRS complex to enable an

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COMPARISON OF 24 VS 12 HOURS OF AMBULATORY ECG MONITORING 269

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Table 1—Patient Population

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. of patients</th>
<th>No. of recordings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1—CAD (no medication)</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Group 2—CAD (on medication)</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Group 3—Miscellaneous heart disease or normal (no medication)</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Group 4—Miscellaneous heart disease or normal (on medication)</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>TOTAL</td>
<td>54</td>
<td>72</td>
</tr>
</tbody>
</table>

CAD = Coronary artery disease

accurate arrhythmia diagnosis. When this lead yielded a small QRS complex amplitude, a modified V₃ lead was used. The patient was instructed to carry on his normal daily activity and a careful diary of the level of activity, symptoms, and medications was kept throughout the entire 24 hours.

**ECG Data Analysis**: a computerized ambulatory ECG tape processing system developed at Stanford Medical School was used to analyze the 24 hours of ECG data. Using a PDP-12 computer, the RR interval is plotted versus time together with simultaneous QRS duration, QRS vector direction, and noise level indicator plots. Premature, late, wide, and abnormal QRS configurations are identified from the plots by visual inspection, with actual ECG rhythm strips printed out frequently to confirm the arrhythmia diagnosis. Repetitive patterns in all three plottings (i.e., same characteristics in the RR interval, QRS duration, and QRS vector direction plot) are easily recognized and not sampled repeatedly; however, episodes suggestive of serious arrhythmias, such as paroxysmal ventricular or atrial tachyarrhythmias, or two premature beats in a row, were always confirmed by rhythm strips. Noise can simulate all types of arrhythmias in our technique, but frequent sampling of ECG and recognition of certain pattern areas make the arrhythmia diagnosis quite accurate and will enable us to identify periods of artifacts quite easily.

Each 24-hour recording was divided into two similar periods of 12 hours each. The second 12 hours included the entire period of sleep. The 12-hour period that showed the first occurrence of the following events was noted: 1) ten or more peak PVC's per 15 minutes; 2) two (pairs) or more (ventricular tachycardia) PVC's in a row, ventricular bigeminy and trigeminy, multiformal PVC's, and episodes of three or more PAC's in a row (supraventricular tachycardia). Although the incidence of isolated PAC's were not included as a criterion to include the patients' ECG recording in this study, the frequency of this arrhythmia is also presented in the results.

**RESULTS**

In the 72 recordings, 233 separate episodes of arrhythmias (as defined previously) were identified. Of these, only 38 (16 percent) were recorded for the first time in the second 12 hours of the recording (Fig 1, Table 2). No significant differences were noted between the four groups of patients. When we analyzed the type of arrhythmia, the second 12 hours identified new events in 13 percent of cases for isolated PAC's and 19 percent for frequent PVC's; however, 12 of 25 (48 percent) episodes of SVT occurred in the last 12 hours of the recording (Table 2, Fig 1).

**Influence of Sleep**

Sleep was associated with the occurrence of new arrhythmias in from 25 percent for ventricular bigeminy/trigeminy to 100 percent for a single case of ventricular tachycardia, the only one detected in the second 12 hours (Fig 2).

There were 12 episodes of short bursts of supraventricular tachyarrhythmia in the second 12 hours of recording, of which 8 occurred during sleep. Only 2 recordings showed frequent PVC's for the first time during sleep. This corresponds to only 4

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**Figure 1.** Detection of new arrhythmias in the second 12 hours of a 24-hour ambulatory ECG recording. CAD = Coronary artery disease. See Table 1 for definition of groups.

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percent of the 51 recordings showing frequent ventricular ectopic activity. In fact, sleep is usually associated with a marked decrease in the incidence and frequency of ventricular irritability (Fig 3). However, short runs of paroxysmal supraventricular tachycardia occurred in 31 percent (8 in 25) of the cases only during sleep.

**DISCUSSION**

Ambulatory ECG monitoring has been an important improvement over the resting 12-lead ECG to detect arrhythmias.** It has been shown that increasing the length of the recording period over 12 hours increases the probability of detecting such serious arrhythmias as ventricular tachycardia and pairs of PVC's.** The identification of these events

![Graph](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/20963/)

**Figure 2.** Influence of sleep on the occurrence of arrhythmias within the second 12-hour period of a 24-hour ambulatory ECG recording. CAD = Coronary artery disease.

**Figure 3.** Influence of sleep on the frequency of PVC's. Graph based on data from 30 recordings with frequent PVC's. The mean PVC's/15 minutes shows a binominal distribution during the awake and asleep period. However, during sleep there is a marked reduction in the frequency of PVC's with 19 of 30 recordings having less than one mean PVC/15 minutes.

**Table 2—First Occurrence of Arrhythmias During 24-Hour Ambulatory ECG Monitoring**

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>No. rec.</th>
<th>Events occurring first 12 hours (No. tapes)</th>
<th>Events occurring only 2nd 12 hours (No. tapes)</th>
<th>Total Events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>≥ 10 PVC/15 min</td>
<td>PVC</td>
<td>VT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>72</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

All groups: 72, 47, 26, 8, 34, 28, 39, 13, 4, 6, 1, 4, 5, 6, 12, 195, 38, 233.

No. rec. = Number of recordings
10 PVC's/15 min: 10 or more peak PVC's/15 min
PVC's = Premature ventricular contractions
Pairs = Two PVC's in a row
VT = Ventricular tachycardia
Big/Trig = Bigeminy and/or trigeminy
Multi PVC's = Multiform PVC's
PAC's = Premature atrial contractions
SVT = Supraventricular tachyarrhythmias (3 or more PAC's in a row)
is particularly critical in epidemiologic studies to assess prognosis of patients with coronary artery disease.\textsuperscript{4,6} Several authors have reported that any occurrence of certain ventricular arrhythmias is associated with an increased risk for sudden cardiac death, particularly if the patient has proved CAD, or is post-myocardial infarction.\textsuperscript{4,6} Whether PVC frequency range or any occurrence at all of certain arrhythmias has the same risk for sudden death is not presently clear. We have previously shown that there is marked variability in the incidence and frequency of ventricular arrhythmias on a week-to-week basis of 2 or more 24-hour ambulatory ECG recordings.\textsuperscript{8} This variability included a spontaneous decrease in PVC frequency of over 50 percent to an increase as high as 1200 percent. Complex ventricular arrhythmia incidence also varied markedly from week to week. These data would suggest that to fully characterize the incidence and frequency of ambulatory arrhythmias, two or more 24-hour recordings are required. However, our data indicate that 80 percent of patients’ ambulatory awake arrhythmias can be detected and characterized on a 12-hour recording.

The problems of detecting and quantitating ambulatory ventricular arrhythmias have previously made it difficult to assess the efficacy of antiarrhythmic therapy. The use of an automated system for PVC detection and counting will now allow PVC detection, counting, and analysis by time, activity, and medications taken. When monitoring antiarrhythmic therapy, it is important to obtain at least one 24-hour recording to characterize the occurrence of arrhythmias in relation to activity and time. However, if the patient is one of the 75 percent whose PVC’s markedly decrease during sleep, there appears to be little value in obtaining additional 24-hour rather than 12-hour recordings for assessment of antiarrhythmic therapy effectiveness.

The 24-hour, continuous ECG monitoring period enabled us not only to double the length of the recording, but also to record the ECG during sleep. Generally, sleep is associated with marked decrease in the frequency of ventricular arrhythmias,\textsuperscript{7} although a small group of patients may show the opposite phenomena with sleep-associated ventricular arrhythmias. In our study, the addition of another 12 hours of ECG monitoring added the detection of a new ventricular arrhythmia event in less than 20 percent of the cases. It is important to identify the patient group in which either the sinus bradycardia or other conditions of sleep are associated with occurrence of new, serious ventricular arrhythmias. For example, one patient with CAD in our study had the only episode of ventricular tachycardia while asleep. It was asymptomatic and did not awaken him so that it is difficult to assess its importance. Thus one of nine episodes of VT occurred only during sleep in this series. Whether the occurrence of sleep-induced, serious ventricular arrhythmias has a different implication for prognosis is not apparent from our study and will require long-term epidemiologic studies.

Only 8 percent of the 72 recordings revealed the occurrence of frequent PVC’s for the first time during the second 12-hour period. These data are consistent with other reports showing a marked decrease in PVC frequency during sleep.\textsuperscript{7,9} When we analyzed the 30 recordings showing frequent PVC’s during awake periods, there was a marked reduction to less than one mean PVC/15 minutes in 19 of the recordings, or 63 percent (Fig 3). We have previously shown that this pattern of PVC frequency during sleep for any individual patient is quite reproducible.\textsuperscript{8} Once the sleep period is characterized for a patient, there appears to be little additional information from repeated monitoring periods during sleep. In the small group of patients with an increase of ventricular arrhythmias during sleep, repeated monitoring may be required. Whether sleep suppresses PVC’s or not may well imply a different etiology for the arrhythmia and suggest a different prognosis. Our patient groups were of insufficient size to indicate whether CAD patients behaved differently in regard to PVC frequency during sleep.

Short bursts of paroxysmal supraventricular tachyarrhythmias occurred frequently during sleep in our study. This unusually high incidence during sleep has also been reported by Lown et al.\textsuperscript{9} We suspect that our improved system of arrhythmia detection and quantification is responsible for this higher incidence. Sympathetic nerve withdrawal during sleep and sinus bradycardia may well play a role in the frequency of these tachyarrhythmias during sleep, as suggested by Lown et al. On the basis of these data, we suggest that 24-hour ECG monitoring be performed when there is clinical suspicion of supraventricular arrhythmias.

**Conclusion**

The second 12-hour period of a 24-hour ambulatory ECG recording revealed new ventricular arrhythmias in 16 percent of 72 recordings analyzed. The second 12-hour recording period did permit characterization of PVC frequency in response to sleep with only 8 percent of patients showing an increase compared to their PVC frequency rate while awake. Whether the change in the occurrence or frequency of ventricular arrhythmias during sleep is important for prognosis is not
presently known and requires longterm epidemiologic studies. For epidemiologic studies relating serious ventricular arrhythmias to prognosis, it appears that a 12-hour recording is sufficient for detection of 84 percent of the arrhythmias. On the basis of our data, we suggest a single 24-hour ambulatory ECG recording to fully characterize the incidence and frequency of serious ventricular arrhythmias during awake and sleep periods. Additional ECG recordings for assessment of arrhythmia occurrences, efficacy of antiarrhythmic therapy or re-evaluation can be accomplished with a 12-hour recording in 80 percent or more of patients. In contrast, over 50 percent of supraventricular arrhythmias occurred for the first time during sleep, and a 24-hour recording is suggested for optimal detection of these arrhythmias.

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REFERENCES

Historic Records in Tree Rings

Each year of a tree’s growth is recorded by the addition of another ring to the cross section of its trunk. If the ring is wide, it indicates that growing conditions that year were favorable, with ample sunlight and moisture. If it is narrow, it suggests an abnormally dry season, or crowding by the tree’s competitors in a dense forest, or some other unfavorable circumstance that reduced normal growth. By comparing tree rings, scientists have been able to compile weather charts reaching back hundreds of years, and the rings of trees cut centuries ago can throw an illuminating light on the activities of man as well. Until they were rediscovered in 1888, the Mesa Verde cliff dwellings of the Pueblo Indians had been silent and deserted for hundreds of years. About A.D. 1100 the Pueblos had moved into the most advanced stage of their civilization, which lasted for nearly two hundred years, but sometime in the fourteenth century their strange cliff cities had been evacuated, never to be inhabited again. By examining the tree poles used in constructing their buildings, scientists concluded that a terrible drought had forced the inhabitants to depart about the year 1290: the rings of the trees, preserved by the dry climate, revealed that they all had been cut before that date.