

DIAGNOSTIC ADVANTAGES OF A LONG-TERM HOLTER ECG MONITORING COMPARED TO A STANDARD 24-HOUR MONITORING

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Longer observation periods have been proven to increase the diagnostic value of Holter ECG monitoring for paroxysmal atrial fibrillation mainly. The aim of this work was to study the diagnostic efficacy of a long-term ECG monitoring in detecting various types of arrhythmias and to assess the uneven distribution of arrhythmias over different observation days. In this study 27 patients were examined, including 13 men and 14 women with a mean age of 42.8 ± 10.8 years, their complaints suggesting various types of tachy- and bradyarrhythmias. Compact recorders and original software were used. ECG recording time was 5-7 days. Using quantity criteria characterizing the level of uneven inter-day distribution of arrhythmias, advantages of long-term observations over a 24-hour monitoring were confirmed for such arrhythmias as sinus pauses over 2.5 seconds, a second degree AV block, paroxysmal supraventricular tachycardia, single and paired ventricular extrasystoles, ventricular salvos, ventricular tachycardia.

Keywords: Holter monitoring, long-term ECG monitoring, arrhythmia

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ДИАГНОСТИЧЕСКИЕ ПРЕИМУЩЕСТВА МНОГОСУТОЧНОГО ХОЛТЕРОВСКОГО МОНИТОРИРОВАНИЯ ЭЛЕКТРОКАРДИОГРАММЫ ПЕРЕД СТАНДАРТНЫМ 24-ЧАСОВЫМ ИССЛЕДОВАНИЕМ

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Повышение диагностической ценности холтеровского мониторинга ЭКГ при увеличении длительности исследования убедительно доказано в основном в отношении пароксизмальной фибрилляции предсердий. Цель исследования — изучение диагностической эффективности метода многосуточного мониторинга ЭКГ в выявлении различных видов аритмий, оценка неравномерности распределения аритмий между различными сутками наблюдения. Обследованы 27 пациентов (13 мужчин, 14 женщин, средний возраст — $42,8 \pm 10,8$ года) с жалобами, вызывающими подозрение на наличие различных видов тахи- и брадиаритмии. В исследовании использованы малогабаритные кардиорегастраторы и оригинальное программное обеспечение. Длительность регистрации ЭКГ составила 5–7 сут. С использованием предложенных количественных критериев, характеризующих степень неравномерности межсуточного распределения аритмий, подтверждены преимущества многосуточных исследований перед 24-часовым наблюдением в отношении таких аритмий, как паузы более 2,5 с, АВ-блокада II степени, пароксизмальная суправентрикулярная тахикардия, одиночные желудочковые экстрасистолы, парные и групповые желудочковые экстрасистолы, желудочковая тахикардия.

Ключевые слова: холтеровское мониторирование, многосуточное мониторирование ЭКГ, аритмия

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By now, various authors have proved that longer observation periods increase the informative value of ECG monitoring. For example, G. Senatore et al. [1] compared the incidence of asymptomatic recurrences of atrial fibrillation (AF) in patients who had undergone radiofrequency catheter ablation of AF by a 90-day continuous transtelephonic ECG monitoring, standard

ECG recorded 12, 24 and 36 hours after ablation and on the 14th, 30th and 120th days after ablation, and 24-hour Holter recording on the 30th and 120th days after ablation. It was demonstrated that long-term transtelephonic ECG monitoring was of a higher diagnostic value and decreased the success of ablation from 86 %, as detected by two other methods, to 72 %.

N. Dagres et al. [3] studied the influence of Holter duration on the detection of AF recurrences after ablation for this arrhythmia and established that a 24-hour Holter would have detected 59 % of patients with recurrences, a 48-hour Holter — 67%, a 72-hour Holter— 80 %, a 4-day recording — 91 % of all recurrences identified upon completing the 7-day observation. T. Hanke et al. [4] compared the effectiveness and accuracy of cardiac rhythm assessment in patients with prior standard radiofrequency catheter ablation by standard ECG Holter monitoring and long-term monitoring with an implantable medical device (IMD) (Reveal XT 9525, Medtronic Inc., USA) over a 3-month period. During the 24-hour surveillance, sinus rhythm was documented in 53 readings, but confirmed by the IMD in 34 cases only. D. Jabaudon et al. [5] showed that 7-day ambulatory ECG monitoring using an event-loop recorder enables to detect AF episodes more effectively than standard ECG and standard Holter monitoring. The effectiveness of standard ECG was 2.7 %; Holter monitoring identified another 5 % among those patients whose standard ECG records were of no diagnostic value; event-loop recording identified another 5.7 % of AF in patients with a normal ECG and a normal 24-hour Holter. D. Andresen et al [6] demonstrated the advantages of long-term ECG monitoring in the detection of complex ventricular tachyarrhythmias.

A positive diagnostic experience in using continuous long-term ECG monitoring for the detection of various arrhythmias has been described by a number of Russian researchers [7–10]. Long-term ECG monitoring is successfully applied when deciding on the appropriate antiarrhythmic therapy [11, 12].

It is important to note that the majority of previous studies focused on such arrhythmias as paroxysmal atrial fibrillation. Other arrhythmias, including those of clinical significance, were studied less. Little attention is paid to studying the uneven inter-day distribution of arrhythmias. Qualitative criteria showing the advantages of long-term studies have been insufficiently elaborated.

The aim of this study is to investigate the diagnostic advantages of long-term Holter monitoring over a standard 24-hour observation in detecting different types of arrhythmias, excluding AF, and to analyze the uneven inter-day distribution of arrhythmias.

METHODS

We examined 27 patients (13 male and 14 female) with a mean age of 42.8 ± 10.8 . The inclusion criteria were as follows: complaints of infrequent subjective symptoms of arrhythmia (1-4 times a week), such as sudden palpitations, an acute sensation of abnormal heart activity, blackouts and sudden intense dizzy spells. Written informed consent was obtained from all patients.

For long-term ECG monitoring portable 3-channel "Machaon-03" recorders (Altonika, Russia) were used. These recorders allow for 7-day recording without battery replacement. The records were processed by the original software designed by the authors of this work. It enables to process and analyze a 7-day long 3-channel record without splitting it into separate 24-hour long segments, in one pass. Previously, the software was tested on the ECG MIT-BIH database [13–15] using a traditional method [16]. The accuracy of R-peak automatic detection was as follows: sensitivity (SE) of 99.56 %, positive predictive value (+P) of 98.67 %. A test was conducted using the Russian Society of Holter Monitoring and Non-invasive Electrophysiology database [17] with the following R-peak detection accuracy: sensitivity (SE) of 99.8 % and positive predictive value (+P) of 99.5 %.

Patients were distributed into groups based on the ECG recording duration: 21 patient had a 7-day recording, 5 patients — a 6-day recording, 1 patient — a 5-day recording. The mean duration of observation was 6 days 17 hours (161 hour).

We analyzed 7 types of arrhythmias: sinus pauses over 2.5 seconds, second degree AV block, supraventricular extrasystoles, including paired and salvos, paroxysmal supraventricular tachycardia, single and paired ventricular extrasystoles, ventricular salvos, ventricular tachycardia.

In each case the observation duration was nominally divided into 24-hour intervals. The number of various rhythm and conduction disorders in each interval was calculated. Then the uneven distribution of arrhythmia episodes over the observation period was analyzed based on the difference in their number in every 24-hour interval.

For qualitative evaluation of the results, we suggest the following parameters:

- PN1 positive number of patients — number of patients with the arrhythmia of interest detected in only one of all 24-hour intervals, whereas in the rest of 24-hour intervals this arrhythmia was not detected at all;

- PN1 positive number of patients, % — a proportion of patients with only one diagnostically significant 24-hour interval to the total number of patients with detected arrhythmia of interest, expressed as a percentage For example, the studied type of arrhythmia was detected in 7 patients; 2 of them recorded arrhythmia only during one 24-hour interval of the total observation period. Thus, the percentage of PN1-positive number of patients will be 28.5 %;

- PN1 negative number of patients — number of patients who did not have the arrhythmia of interest registered within at least one of 24-hour intervals, but had it documented on other days;

- PN1 negative number of patients, % — a proportion of patients with at least one 24-hour interval free of the arrhythmia of interest, to the total number of patients in whom this arrhythmia type was detected, expressed as a percentage. For example, a given type of arrhythmia was detected in 8 patients, 5 of them had a day when this type of arrhythmia was not registered. The percentage of PN1-negative number of patients will be 62.5 %;

- PD24 — a probability of detection of the arrhythmia of interest in case the study would have covered a 24-hour interval only. For each patient, this value was calculated as a proportion of the number days when arrhythmia was detected, to the total number of days in the observation period, and expressed as a percentage. For example, if arrhythmia is identified in 3 out of 6 24-hour intervals (a 6-day monitoring), PD24 will be 50 %;

- VC — a variation coefficient, a non-uniformity index, calculated as a ratio of standard deviation of arrhythmias number in each observation day to their daily average in a given patient.

RESULTS

Results of data analysis obtained during the continuous long-term ECG Holter monitoring, are presented in the table below.

Using the quantity criteria listed above the advantages of long-term ECG recording over a standard 24-hour Holter were demonstrated. As the table suggests, the standard 24-hour ECG monitoring can fail to detect potentially dangerous arrhythmias.

When summarizing the results of all arrhythmia cases analyzed in this work, the following mean values were obtained. The probability of detecting an arrhythmia within a 24-hour surveillance was 51.4%, compared to long-term observations.

Parameters of detection various arrhythmia types in a long-term surveillance

Parameters	Supraventricular extrasystoles	Single ventricular extrasystoles	Paroxysmal supraventricular tachycardia	Sinus pause over 2.5 sec	Second degree AV block	Paired and group ventricular extrasystoles	Ventricular tachycardi	Mean values for all arrhythmia types
Number of patients with a given type of arrhythmia	27	26	15	3	3	13	5	-
PN1 positive number of patients	0	2	7	2	1	8	3	-
PN1 positive number of patients, %	0	7.7	46.7	66.7	33.3	61.5	60	39.4
PN1 negative number of patients	3	15	13	2	3	12	5	-
PN1 negative number of patients, %	11.1	57.7	86.7	66.7	100.0	92.3	100.0	73.5
PD24, %, mean valu	98.4	71.2	39.8	29.4	55.6	33,2	31.9	51.4
VC, mean value	61.4	106.7	181.8	203.3	147.5	198.5	199	156.9

Arrhythmia was detected in only one 24-hour interval of the total observation period in 39.4% of cases. In 73.5% of cases there was at least one 24-hour interval when arrhythmia was not present.

A mean value of arrhythmia variation coefficient was 156.9, which is 5 times higher than a standard threshold value for a uniform distribution.

Examples illustrating the uneven distribution of arrhythmia episodes between different days are presented below.

Patient S., 46 years of age, male, sought medical advice with a cardiologist at Regional Clinical Hospital no.1. The patient complained of sudden palpitations which lasted from several seconds up to several minutes and occurred once or twice a week, mainly in the evening or at night. The patient had had those symptoms for about a year. In spite of the fact that except palpitations no other symptoms were present, those episodes caused a considerable psychological discomfort for the patient. The cardiologist suspected ventricular dysrhythmia. Shortly before that the patient had undergone a 24-hour Holter that only registered singular supraventricular extrasystoles. We conducted a 7-day Holter monitoring. During the analysis of a 4th day record, a single episode of paroxysmal supraventricular

tachycardia was detected with the heart rate of up to 145 beats per minute and the duration of 5 seconds (Fig. 1), which matched the patient's subjective sensations. It was the only episode within a 7-day observation. As a result, it was proved that arrhythmia episodes in this patient were of low risk, which made it possible to cancel the aggressive antiarrhythmic treatment planned before.

Patient L., 32 years of age, male, sought medical advice with a cardiologist at Regional Clinical Hospital no.1. The patient complained of periodic short dizzy spills and presynopes that occurred approximately once a week. On the 6th day of a 7-day monitoring the patient suddenly felt intense dizziness, which coincided with the episode on the tape consisting of two consecutive sinus pauses of 2.8 and 3.1 seconds long (Fig. 2). This episode of sinus node suppression was a single indication of bradycardia over the whole 7-day recording. The patient was referred to surgeons to decide on the pacemaker implantation.

Patient P., 62 years of age, female, sought medical advice with a cardiologist at Regional Clinical Hospital No 1. The patient complained of periodic short sudden anxiety episodes, palpitations, chest discomfort and pressure unrelated to physical exercise. Those episodes had been present for several months

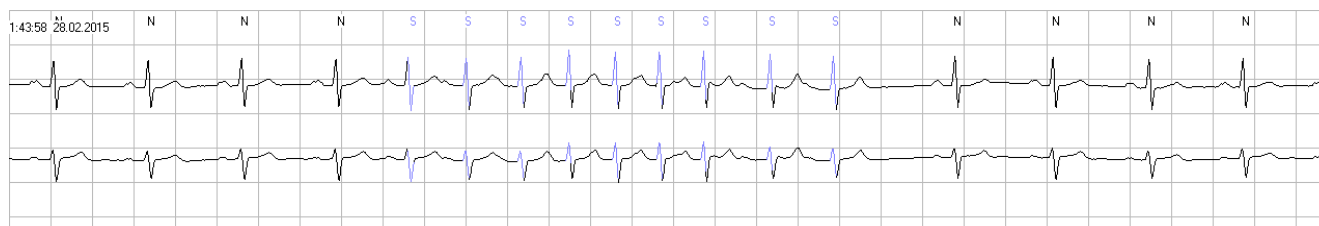


Fig. 1. A single episode of paroxysmal supraventricular tachycardia on the 4th day of the 7-day observation

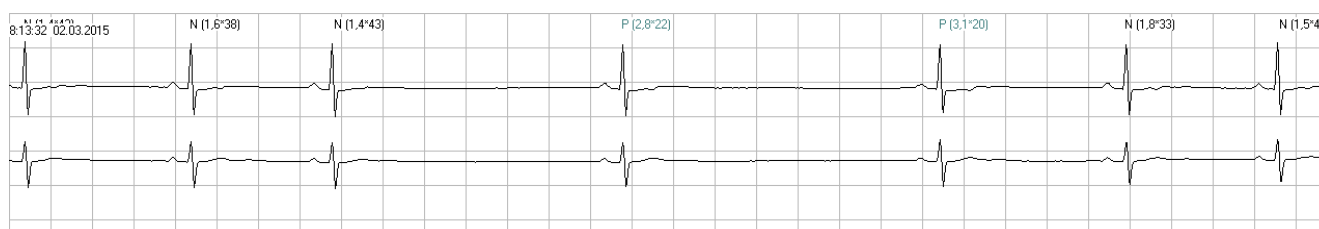


Fig. 2. Subsequent sinus pauses of 2.8 and 3.1 sec resulting from sinus node suppression

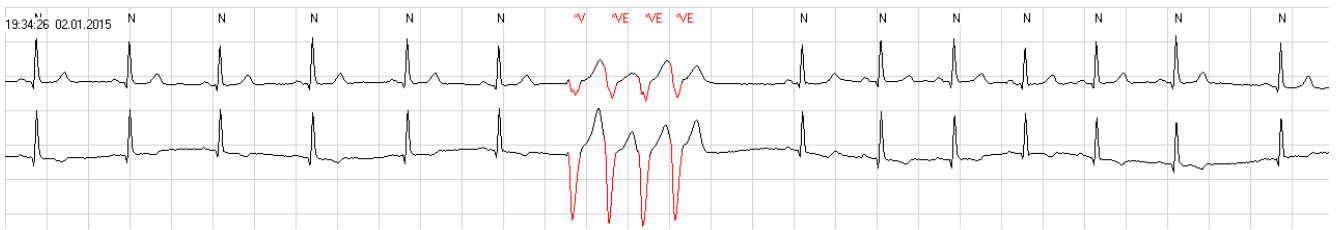


Fig. 3. A single episode of paroxysmal ventricular tachycardia on the 4th day of the 7-day study

and occurred once or twice a month, but became more frequent (2-3 times a week) by the time of the consultation. To exclude a cardiovascular disease, a 7-day monitoring was conducted. A single episode of ventricular tachycardia was documented on the 4th day of the observation (fig. 3), confirmed by the patient's complaints. The patient was referred to a cardiologist to decide on the appropriate antiarrhythmic therapy.

DISCUSSION

Different authors have shown that longer observation periods increase the informative value of ECG monitoring. Increased observation duration was achieved by different means and in all cases resulted in a higher informative value of the examination. However, less attention was paid to investigating of how uneven the inter-day arrhythmias distribution is. We believe that the data we obtained prove that in patients with infrequent clinical symptoms of heart dysrhythmias, the inter-day distribution of arrhythmias is significantly uneven. Cases of total absence of the studied arrhythmias over a period of several observation days and cases of dysrhythmias recorded only in one 24-hour interval of the whole observation period make up quite a big proportion. Such distinct unevenness points to a very high probability of false positive diagnostic results within this group of patients in case if only a one-time 24-hour Holter monitoring is performed.

Longer (up to 7 days) observation increases the probability of detecting various arrhythmias. The results of this study suggest that the above-said is true not only for paroxysmal AF, but for other arrhythmias as well. Still, a longer surveillance is more expensive as compared to a 24-hour observation, which is the reason why a 7-day monitoring cannot be recommended

as a routine procedure instead of a standard 24-hour Holter in every case.

Longer observation (up to 7 days) can be recommended if a 24-hour monitoring has proved to be of no informative value in patients with typical and distinct complaints and infrequent (1-4 times a day) rhythm and conduction defects.

Noninvasive 7-day observation is definitely not as long as an observation based on the usage of an implantable medical device, but it has a number of advantages based on other parameters: no implantation surgery is required, it is cheaper, the recorder can be used many times, it offers a possibility for continuous ECG recording.

CONCLUSIONS

The quality criteria we suggest enable to objectively assess the inter-day distribution of arrhythmias and clearly show their irregular occurrence.

In patients with infrequent arrhythmia symptoms, a considerable uneven inter-day distribution of arrhythmias is observed. This conclusion applies not only to paroxysmal atrial fibrillation, but to other arrhythmias as well.

During the superlong 5-, 6-, 7-day Holter observations there is a possibility to extract more valuable diagnostic information than during standard ECG monitoring. The probability of detecting arrhythmias in case of their infrequent occurrence (1-4 times a week) increases considerably. This is particularly true for clinically significant arrhythmias, such as sinus pauses over 2.5 sec, second degree AV block, paroxysmal supraventricular tachycardia, paired ventricular extrasystoles, ventricular salvos, ventricular tachycardia. However, the advantages of using this method for supraventricular extrasystole diagnosis are disputable.

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