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Ventricular arrhythmias are not a short-term reproducible phenomenon – why long recording monitoring is necessary

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Abstract

Background: The variability of ventricular arrhythmias (VA) among different days of the week is not well detected by one-day Holter monitoring.
Aims: To evaluate whether there are differences in VA distribution pattern during long recording period.
Methods: The EKG was recorded for 14 h per day during 7 days by Holter system in 34 consecutive pat ventricular couplets and non-sustained ventricular tachycardia (NSVT) recording from patients provided graphic data. We applied the Hurst method (H Coefficient) which evaluates whether a repetitive phenomenon is random or not. When the H is >0.5 and <1 means it is not random and implies a long-term memory effect. Considering the arrhythmic variability, the data were also analyzed by repetitive ANOVA comparing incidence of arrhythmias among the days.
Results: Isolated PVCs and ventricular couplets during 98 h recording provided graphic of the occurrence. A trend of increasing and decreasing of arrhythmias was observed which looks erratic. The H coefficient, however, was significantly >0.5 for all patients. Repeated ANOVA showed statistic difference among days in 31 patients with isolated PVCs; in 26 with ventricular couplets and 19 with NSVT when analyzed per hour during week days ($p < 0.05$).
Conclusion: PVCs, ventricular couplets and NSVT are not a random phenomenon. Our data suggest the occurrence of ventricular arrhythmias had no similarity among the days, making unlikely that a single Holter recording for 24 h may capture this phenomenon.

Keywords: Ventricular arrhythmia; electrocardiogram; Holter monitoring

Introduction

Holter monitoring of the electrocardiogram (EKG) has been used for over 40 years to diagnosis and follow-up of patients with cardiac arrhythmias. The EKG is usually recorded over a 24–48 h period which allows documentation, quantification and association with clinical events and symptoms [1–3].

For several years, the most common parameter used to determine the efficacy suppression of ventricular arrhythmias by Holter monitor was the quantitative reduction of such events to a specific level (75% reduction in isolated or coupled ventricular premature complexes; 90% reduction in ventricular tachycardia) [4–6].

However, during the 1980s some authors reported that ventricular arrhythmias, when monitored for longer periods, occurred with substantial variability and may appeared unpredictable [7–10].

Recently, the technological evolution has allowed new devices with smaller recorders and flashcard technology which collect data continuously for periods up to 2 weeks of recording. The major advantage of this technology is the ability to continuously record EKG data. The practical issue that still remains without answer is whether 24 h of recording is sufficient to analyze the arrhythmias in such heterogeneous populations [11].

In nature, the majority systems behave non-linearly. The human systems are indubitable complex and the dominant scientific approaching has been to investigate

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with the simplest methods. Some phenomena, however, are best described by other mathematic principles. In the field of cardiac arrhythmias, the predominant view is to report this phenomenon like a linear behavior which implies a presupposition of bell-shape distribution. This manner has not been very successful when dealing with ventricular arrhythmias.

In this paper we combine Hurst model, applied to analyze non-linear manifestation and traditional statistical tool to evaluate the variability of ventricular arrhythmias. The Hurst Exponent (HE) was initially applied to study non-linear phenomena likewise flooding, high performance multi-media networks and stock markets etc. This model aims to prove that a phenomenon, despite apparently behaving in a random way, can present a certain degree of consistency or dependency over a considerable period of time [12–14].

So, the aim of the present study was to analyze the temporal dynamics of ventricular arrhythmias over several days to test the possibility that this type of cardiac arrhythmia in fact does not behave as a truly unpredictable random phenomenon.

Methods

Forty patients consecutively were selected from the arrhythmias outpatient clinic at Cardiology Department of Sao Paulo Federal University. All had isolated premature ventricular contractions (PVCs), ventricular couplets and non-sustained ventricular tachycardia detected by 24 h Holter monitoring. Six patients were excluded because their tracings showed electrical interference. Patients signed an informed consent approved by the medical ethics committee. All data were collected before any pharmacologic treatment.

To perform this study, the monitors with three leads were attached on Mondays and removed on Sundays. Thus, individuals were recorded for 14 h during each of 7 days from 8 am to 10 pm, to let the skin rest until the following day. All Holter monitoring were well tolerated and EKG tracings were revised by one of the authors (MCR).

Recording over a period of 98 h allowed us to analyze the pattern of isolated premature ventricular contractions (PVCs) and ventricular couplets with graphs. The numbers of these arrhythmias were recorded by hours. For example, between 3 pm and 4 pm, 30 ventricular couplets and 103 isolated PVCs were registered.

A computer program was developed by Cardios Sistemas Software, São Paulo, Brazil to enroll the time of arrhythmic events to the exact moment of their occurrence. In this regard time series were constructed with hours, minutes and seconds defining the moment of each arrhythmic episode. For example, an isolated VPC was registered at 3:30:26 pm (3 hours: 30 minutes: 26 seconds pm).

To test the hypothesis that arrhythmias are a repetitive phenomenon subordinated to recent or late temporal events, we used the Hurst Exponent (HE) or Rescaled Range analysis – R/S [15].

The method in question is based on the mean, standard deviation (SD), and range at determined intervals of non-superimposed data throughout the time series. The end result is a dimensionless quantity called HE.

Interpretation of the Hurst Exponent

According to the simulations carried out by Hurst, HE is equal to 0.50 when one system is independently distributed in relation to the non-superimposed time intervals (random). After conducting simulations that confirmed his findings, the following interpretation of the Hurst exponent, in terms of randomness and persistence, was suggested:

$0.50 < H \leq 1$ implies a persistent time series that is characterized by the effects of long memory, independent of the timescale. It means that daily changes are correlated with future daily changes and the weekly changes are correlated with future weekly changes. Theoretically, what happens today influences the future.
$0 \leq H < 0.50$ signifies an anti-persistent system. An anti-persistent system covers less distance than a random system ($H = 0.50$). This indicates that the system under study has a stable average, but we cannot make any presuppositions about the cases.

We examined an occurrence of cardiac arrhythmias in each patient for similarity to the characteristics of the series described by Hurst. We applied R/S analysis to determine the Hurst Exponent for each patient's series according to the methods described in the Appendix.

The patient's data were also analyzed by repetitive analysis of variance (repetitive ANOVA) comparing the days of week among the patients. This procedure had the objective to detect whether the arrhythmic patterns were stable or not during the 98 h of recording. From each individual patient, 14 daily registered were compared among themselves. It means that 14 hours registers of day one was compared with the subsequent days, consecutively, until day 7.

The SPSS software version 19 was applied to analysis of variance for repeated measures. It was considered statistically significant p-value < 0.05.

Results

In this study, 34 patients were selected between 25 and 68 years of age distributed in both sexes. The demographic data for the patients are summarized in Table 1. The majority was hypertensive or had ischemic heart disease with mean ejection fraction of 0.60 (SD ± 0.15). All patients were referred for evaluation because of palpitations and arrhythmias were found during their 24-h Holter monitoring. None had cardiac failure manifestations and all patients were in stable clinical conditions. Fifteen patients were taking ACE inhibitor, 8 diuretics and 6 calcium channel blockers. In this group the potassium level was 4.2 mEq/L.