Requirements on sampling rate in Holter systems for analysis of heart rate variability

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INTRODUCTION

For the investigation of heart rate variability (HRV) in patients threatened by sudden cardiac death the application of Holter techniques is recommended. Very often these Holter systems store the data on analogue tapes and digitize these tapes with a sampling frequency of about 100 to 200 Hz for computer analysis. The aim of this study was to determine the error of HRV analysis via Holter technique caused by the low sampling rate.

METHODS

We investigated 41 ECGs of healthy persons. For every patient a Holter tape and simultaneous a 30 minutes high resolution ECG were recorded (fig. 1). The tapes were digitized on a Holter system with 128 Hz sampling frequency while the high resolution system used 2000 Hz.

After digitizing and extracting of RR intervals by automatic procedures all RR time series were checked by a technician and if necessary edited. A special pattern matching algorithm detected and extracted the 30 minutes Holter RR interval in the 24 hour Holter RR-series corresponding to the equivalent high resolution 30 minutes RR interval. Then 21 parameters from time domain, frequency domain and non-linear dynamics [1, 2] were extracted (fig. 2) from these both 30 minutes time series. As a measure for the error the mean value and the standard deviation of the mean differences (D) between the results from the high resolution (Xh) and from the Holter NN time series (Xn) were calculated as follows:

\[ D = \frac{\text{Abs}(X_h - X_n)}{X_h} \]

DISCUSSION

The surprising high degree of exactness leads to the assumption that an acceptable HRV analysis can be performed with Holter systems using sampling rates above 100 Hz. The relatively low error results from the averaging effect of the calculated measures. Nevertheless we would like to suggest to use sampling frequencies of at least 200 Hz to optimize the ratio of the amount of data and the precision of the analysis.

However, a beat to beat analysis or investigations of minimal fluctuations in heart rate time series often require higher sampling rates [3].

Further on, some important preconditions like the quality of tape synchronization, arrhythmia detection and R-peak detection have to be considered. In this way the accuracy study should be confirmed with other types of Holter systems.

Figure 2: Applied parameters for the HRV analysis. From time and frequency domain we used more traditional measures, from the non-linear dynamics we applied new measures from the symbolic dynamics.

![Image of parameter values](image-url)

Figure 3: Mean error of Holter HRV analysis on the basis of 128 Hz sampling frequency. The total error is 1.8±1.5% (right bar).
ACKNOWLEDGEMENTS

This work was supported by grants from the Deutsche Forschungsgemeinschaft DFG (vo505/2-1) and the Maria-Sonnenfeld-Gedächtnisstiftung, Berlin.

REFERENCES