Automatic Identification of Atrial Fibrillation by Spectral Analysis of Fibrillatory Waves

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Normally, the sinus atrial node regulates the cardiac rhythm, but in case of atrial fibrillation (AF), the sinus atrial node is not able to trigger the atrial depolarizations. Consequently, atrial myocytes start to depolarize in several sites, generating a chaotic electrical activity of cardiac cells. On the electrocardiogram (ECG), this abnormal electrical activity reflects in the appearance of fibrillatory (F) waves, consisting of low-amplitude oscillations at 4-10 Hz. Aim of the present study is to propose an automatic AF identification method based on F-wave frequency analysis in 10 s ECGs.

To this aim, 10 s ECG from 90 healthy subjects (HSs) and 50 AF patients (AFPs) were considered. ECGs were processed by the segmented beat modulation method to reduce components in the F-wave band. Then, the power spectral density (PSD) was computed by using four different methods: the periodogram method (FFT); the Welch's method (WLC); the Yule-Walker's method (YWK) and the Thomson multitaper method (THM). For each PSD, the F-wave frequency ratio (FWFR), defined as the ratio between the spectral area in the F-wave frequency band and the total spectral area, was computed. FWFR ability to discriminate AFPs from HSs was evaluated by analyzing the area under the curve (AUC) of the receiver operating characteristic (ROC), and by computation of sensitivity, specificity and accuracy. Results obtained by using all four methods were all good and comparable. In all cases, median FWFR values were higher ($P<10^{-11}$) in AFPs than in HSs (FFT: 19% vs 34%; WLC: 19% vs 35%; YWK: 20% vs 36%; THM: 18% vs 35%). AUC was at least 85%, whereas sensitivity, specificity and accuracy were at least 84%, 69% and 81%, respectively, as in Table. In conclusion, F-wave frequency evaluation by FWFR represents a promising clinical tool to automatically identify AF.

ROC analysis

	FFT	WLC	YWK	THM
AUC (%)	86	85	86	86
SE (%)	84	90	84	86
SP (%)	78	69	77	74
ACC (%)	82	82	81	82