T-Wave Alternans Influence on Vectocardiographic Parameters

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Abstract

The influence of T-wave alternans (TWA) on vectocardiographic parameters has been presented. Alternations in the length and the angle of T-wave loop vector have been found between odd and even beats in electrocardiograms with detectable T-wave alternans. The study shows the significance of changes of T-wave loop vector length and angle in the process of shaping T-wave alternans signal. The aim of the study was to improve TWA detection process. The results showed the advantages of using vectocardiographic analysis for T-wave alternans detection.

1. Introduction

The continuous need for the noninvasive indices allowing for risk assessment of ventricular arrhythmia is convinced by a large number of sudden cardiac death (SCD) accidents, where ventricular arrhythmias are one of the main reasons [1]. The non-invasive assessment of the cardiac repolarization heterogeneity is of clinical importance. It is generally accepted that the repolarization inhomogeneity facilitates the re-entry phenomena causing the development of life-threatening ventricular arrhythmias, e.g. ventricular tachycardia [2]. At present, there is no generally accepted non-invasive risk index of SCD. T-wave alternans (TWA) is a very promising marker of the vulnerability to ventricular arrhythmia [3]. It is defined as a beat-to-beat change in the T-wave amplitude that repeats every other beat and indicates the spatial heterogeneity of the ventricular repolarization. T-wave amplitude variability is usually too small to be observed by visual inspection of the electrocardiogram, which makes detection of TWA complicated. Methodology of TWA testing should be improved in order to make an analysis of beat-to-beat variability a practical clinical tool for identification those individuals, who are at risk for ventricular tachycardia or fibrillation. Currently, TWA measurements are performed using standard 12 lead ECG or orthogonal XYZ leads. In this study vectocardiographic representation of TWA is proposed. Vectocardiogram represents the spatial distribution of the electrical activity of the heart [4]. Thus, it allows for the evaluation of repolarization phase which, in case of the T-wave alternans, will change from beat to beat. TWA can be observed by analysis of the repolarization wave propagation and their influence on the vectocardiogram. The relations of the changes of the T-wave loop parameters in consecutive heart beats and the T-wave alternans signal detected in electrocardiogram have not been established yet.

2. Methods

The study group consisted of patients (197 pts) with implanted cardioverter-defibrillators (ICD) because of one of the heart pathology: coronary artery disease, hypertrophic cardiomyopathy, dilated cardiomyopathy, long QT syndrome, arrhythmogenic right ventricular dysplasia, idiopathic ventricular fibrillation. Two minute recordings were made during the ventricular pacing at 100 bpm. The stimulation was applied, with the use of ICD electrodes. Upon the analysis of 197 electrocardiograms, 28 (14.3%) patients' ECG recordings were chosen with positive TWA test (detected through the Spectral Method [5]). Orthogonal XYZ lead configuration ECG system was used which allows vectocardiographic analysis. Signals were recorded with sampling frequency of 2 kHz and the amplitude resolution of 22 bits. For each heart cycle, the central T-wave loop vector ($\boldsymbol{T}_{CV}$) was determined from the vectocardiogram. The start point of the vector was located in the beginning of the coordinate system. The end point of the vector was located in the most remote point of the T-wave loop (*TLmax*). The changes in the T-wave vector magnitude and changes in the angles between the vector and three coordinate axes in consecutive heart beats were assessed.

3. Results

The periodic changes in the T-wave loop vector magnitude ($\boldsymbol{T}_{CV}$) as well as in the angles between T-wave loop vector and axis of the coordinate system in frontal (α_{XY}), transverse (α_{XZ}) and sagital (α_{YZ}) planes were detected. Mean values of alternans ratios calculated with use of Spectral Method in obtained signals, formed from the values of above parameters calculated in consecutive beats, for patients with and without TWA are presented in Table 1.

Table 1 The mean values of alternans ratios calculated in: signal of changes of the T-wave loop vector magnitude (T_{CV}) and in signals of changes of the angles between T-wave loop central vector and axis of the coordinate system in frontal (α_{XY}), transverse (α_{XZ}) and sagital (α_{YZ}) planes.

	T_{CV}	α_{XY}	α_{XZ}	α_{YZ}
TWA(-)	-0,34	-0,28	0,63	-0,58
TWA(+)	35,56	92,94	40,96	72,18

TWA(-) – T-wave alternans negative patients
TWA(+) – T-wave alternans positive patients

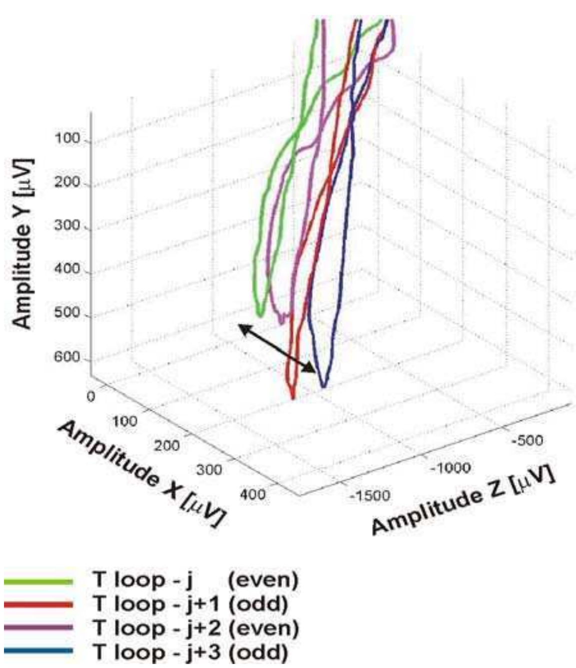

Figure 1. Beat to beat changes in the length and the location of the consecutive T-wave loops.

4. Discussion and conclusions

Vectocardiographic representation of T-wave alternans has been presented. The significant changes in the length and the position of the T-wave loop vector have been found between odd and even heart beats in signals with detectable T-wave alternans. These result shows that there are at least two mechanisms which influence on T-wave alternans signal observed in electrocardiograms. Nonstationarity of T-wave alternans process not only in time but also in space was found which is probably connected with the changes in the propagation of the repolarization wavefront. The results show advantage in using vectocardiographic analysis for T-wave alternans detection.

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