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Editorial

Wavelet transform analysis of surface electrocardiogram as a promising tool for the non-invasive detection of arrhythmogenic substrates

The mechanism of cardiac arrhythmias has been thought to be mainly due to reentry at local myocardial tissue. Formation of a reentrant circuit requires a certain extent of myocardium that shows delayed impulse conduction or disproportionality of refractoriness, i.e., an arrhythmogenic substrate. When an impulse goes through these disarranged areas, the wave front of the impulse may be transformed or distorted by varying degrees. It has been suggested that these transient changes of impulse propagation can evoke irregular electrical activities around the area, resulting in an abnormal potential related to the occurrence of arrhythmias.

Amplification of the electrocardiographic signals is necessary to detect and evaluate these microvolt-level irregular potentials from the body surface. In the past, we have applied signal-averaging techniques to obtain better S/N resolution as a non-invasive approach. Signal-averaged electrocardiogram (SAECG) is now becoming established as one of the useful non-invasive markers for the evaluation of the late potential that is strongly related to sustained monomorphic ventricular tachycardia. However, it is difficult to detect such a small potential within the QRS complex because SAECG is only a time domain analysis. Moreover, transient changes with short duration might cancel each other by averaging of signals. To improve these weak points of time domain analysis of SAECG, various frequency domain approaches, including fast Fourier transform (FFT), have been proposed.

Although FFT has been widely used as a method of frequency domain analysis for evaluating many biological signals, it might override important time components of the information that may vary every moment during signal processing. Short-term FFT might be a solution for the problem, but it is still incomplete. On the other hand, the wavelet transform has emerged over recent years as a novel method for powerful time-frequency analysis and a signal-coding tool favored for the evaluation of complex and unstable signals in various scientific fields. Wavelet transform analysis (WTA) has a unique and epoch-making characteristic that preserves time domain information even during frequency domain analysis. This allows precise time and frequency analysis of various biological signals at one time when applying an optimal mother wavelet in each case. It is readily apparent that this method is highly suitable for the analysis of complex ECG signals, including high frequency arrhythmogenic potentials such as ventricular late potential. It is also expected to be applicable to very transient and trivial beat-by-beat changes in ECG signals even within the large, high energy QRS complex.

Several clinical studies using WTA have already been reported from our department [1–5]. Arrhythmogenic substrates, which appear as abnormal high frequency potentials very transiently in the intracardiac electrogram, were clearly detected from surface ECGs without signal-averaging by applying WTA in patients with hypertrophic cardiomyopathy, prior myocardial infarction, Brugada syndrome, and arrhythmogenic right ventricular cardiomyopathy.

Though trial and error regarding the selection of a mother wavelet in practice may be required in some cases for the effective and reliable detection of each arrhythmogenic substrate, we believe that the WTA of ECG has become one of the most promising tools for non-invasive clinical evaluation of various kinds of arrhythmias.

References

[1] Takayama H, Yodogawa K, Katoh T, et al. Evaluation of arrhythmogenic substrate in patients with hypertrophic cardiomyopathy using wavelet transform analysis. Circ J 2006;70:69–74.

[2] Yodogawa K, Morita N, Kobayashi Y, et al. High frequency potentials developed in wavelet-transformed electrocardiogram as a novel indicator for detecting Brugada syndrome. Heart Rhythm 2006;3:1436–44.

[3] Murata H, Ohara T, Kobayashi Y, et al. Detection of arrhythmogenic substrates in prior myocardial infarction patients with complete right bundle branch block QRS using wavelet-transformed ECG. J Nihon Med Sch 2009;76:291–9.

[4] Yodogawa K, Ohara T, Takayama H, et al. Detection of prior myocardial infarction patients prone to malignant ventricular arrhythmias using wavelet transform analysis. Int Heart J 2011;52:286–9.

[5] Yodogawa K, Morita N, Kobayashi Y, et al. A new approach for the comparison of conduction abnormality between arrhythmogenic right ventricular cardiomyopathy/dysplasia and Brugada syndrome. Ann Noninvasive Electrocardiol 2011;16:263–9.

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