International Journal of Bioelectromagnetism
Vol. 9 No. 2 2007

Distribution of time-frequency power during QRS measured by wavelet transform in cases of myocardial infarction combined with lethal arrhythmias

Takeshi Tsutsumi[a], Daisuke Wakatsuki[a], Hisa Shimojima[a], Youichi Takeyama[a]、Yoshiwo Okamoto[b]

a, Division of Cardiology, Showa University Fujigaoka Hospital, 1-30 Fujigaoka, Aoba-Ku, Yokohama-shi, Kanagawa 227-8501 Japan, Phone:045-971-1151(Ex6303) ,Fax:045-972-6258, E-Mail; tsu-t@kp.catv.ne.jp

b, Department of Electrical,Electronics and Computer Engineering,Facalty of Engineering, Chiba Institute of Technology . 2-17-1Tsudanuma, Narashino-shi, Chiba, 275-0016, Japan

Abstract

By use of continuous wavelet transform(CWT), the arrhythmogenic substance concealed in QRS was investigated. Bipolar limb leads were recorded from normal volunteers (n=25), the patients with MI (n=25) and complicated with ventricular arrhythmias (MI-A , n=12). The time-frequency profile of QRS was measured by CWT and the integrated time-frequency powers between QRS were calculated. Computer simulation were composed of a two dimensional arrangement of 65000 Luo-Rudy model cells. Disk-shaped necroses and slow conduction zone around it were assigned. The frequency power was reduced from 110~ 250Hz in MI ,and in MI-A significant increase in the power from 40~60Hz were noted. When the slow conduction zone was incorporated in the model, the frequency range was shifted to the lower where the spectral power was increased. The lower shift of frequency power in MI-A may indicate the complication with slow conduction.

1. Introduction

For the purpose of searching the arrhythmogenic substance concealed in electrocardiogram (ECG), the time-frequency profile of QRS was measured by continuous wavelet transform (CWT) from the patients with myocardial infarction (MI) plus ventricular arrhythmias. To assess the results of clinical study, a computer simulation was performed.

2. Methods

Bipolar limb leads ECG were recorded through a band pass filter of 350Hz from normal volunteers(n=25), the patients with MI(n=25) and complicated with ventricular arrhythmias(MI-A , n=12). All patients entered the coronary care unit under diagnosis of acute MI. They examined coronary angiogram, if necessary, percutaneous coronary intervention. After the data were saved into PC, the time-frequency profile of QRS was measured by CWT applying Morlet function with 40 scales bands from 10 to 500Hz. The software (BIOMAS ver1.0β ,Elmec Co.Ltd.,Tokyo Japan) developed by our group was used for above calculation. The integrated time-frequency powers between QRS (ITFP) were calculated every frequency band. The dependence of ITFP on the frequency were demonstrated and compared each other group. Computer simulation were composed of a two dimensional myocardium consisting of 65000 model cells. The activities and conduction properties were reproduced by Luo-Rudy phase 1 models and bidomain model, respectively. Disk-shaped necroses modeled as passive resistances and slow conduction zone around it were assigned. The spatial gradient of the membrane potential is proportional to the electromotive force densities. Its integration over the simulated myocardium is used as the pseudo-ECG that has the same dimensional unit as the membrane

potential, namely [mv]. The frequency profile of pseudo-ECG was calculated by FFT.

3. Results

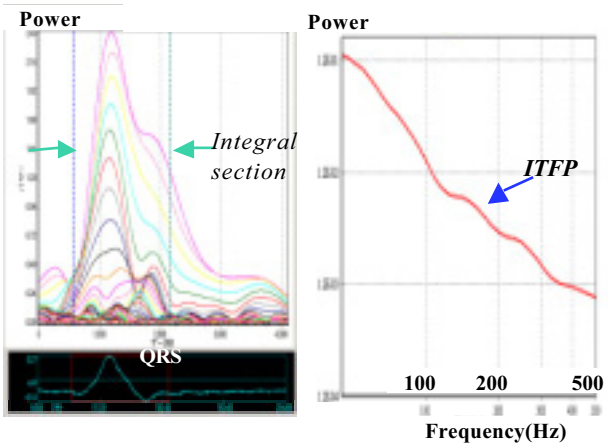

Figure1. Wavelet signal contour and integrated time frequency power (ITFP)
Integral section between QRS indicated by arrows in left panel. The distribution of ITFP on the frequency in a case of patient in right panel

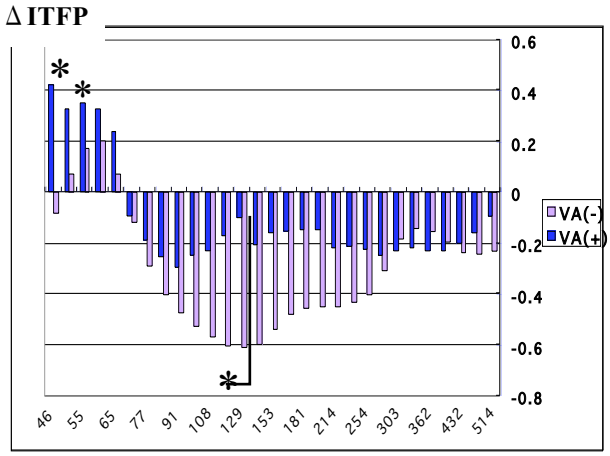

Figure 2. Δ ITFP distribution on the frequency with or without ventricular arrhythmia in patients with myocardial infarction.
Abb. VA;ventricular arrhythmia, **p<0.01,*p<0.05 ; VA vs non-VA

In figure 2, Δ ITFP means averaged ITFP in MI – normal/normal.

The frequency power was reduced from 110~ 250Hz in MI ,and in MI-A significant increase in the power from 40~60Hz were noted, compared with normal group.

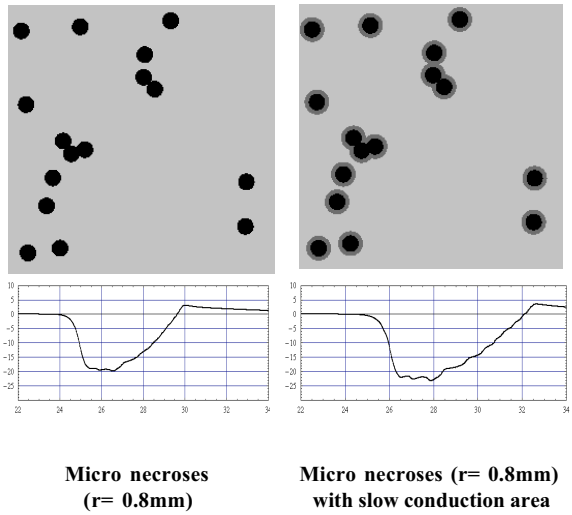

Figure3.The scattered focal necroses incorporated into the simulation model

When the slow conduction zone was incorporated in the model, the major frequency range was shifted to the lower range where the spectral power was increased.

4.Discussion

The lower shift of frequency power in MI-A may indicate the complication with slow conduction that will offer the new information of arrhythmogenic signal.

5. References

[1] .Gramatikov B, Georgiev I. Wavelets as alternative to short-time Fourie transform in signal-averaged electrocardiology. Med and Biol Eng and Comput.1995;33:482-487.
[2] Tsutsumi T, Wakatsuki D, Shimojima H, Higashi Y,Takeyama Y. Analyzing time-frequency power spectrum limited in QRS complex based on the wavelet transform. Inter J of Bioelectromag. 2004; 6(1): http;//www.ijbem.org/volume6/number1/007.htm