Using Wavelet-Based Method for Detection of Atrial Late Potentials and ECG Classification

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Abstract – **The wavelet-based method is proposed to improve detection of low-amplitude components of P wave. Atrial Late Potentials are simulated by solving the Hodgkin-Huxley Equations. Classification of ECG is accomplished by cluster analysis of wavelet coefficients.**

Keywords – **Arrhythmia, Atrial Late Potentials**, **High-resolution ECG, Wavelet transform, Cluster analysis.**

I. INTRODUCTION

The appearance of Atrial Late Potentials (ALP), which are the markers of atrial conduction delay, is associated with the serious types of cardiac tachyarrhythmias. There is a clinical interest in detection of these signals as a non-invasive diagnosis of cardiac diseases and sudden cardiac deaths prevention by high-risk patients' identification.

High resolution ECG (HR ECG) systems detect signals on the order of 1-10 μV thanks to signal averaging techniques. To develop methods for early diagnostics of atrial arrhythmias and to improve technical, informational and algorithmic support of HR ECG the wavelet transform is applied to cardiosignal processing tasks based on ALP detection and ECG classification. The Wavelet basis captures time-frequency information about ALP which is often obscure then HR ECG is analysed in time domain.

II. WAVELET-ANALYSIS FOR ALP DETECTION

To simulate ALP activity the Hodgkin-Huxley Equations were solved and action potentials with low amplitude were added in the P wave terminal part region. ECG both healthy control subject and those with ALP were decomposed to 5 levels by the discrete wavelet transform using Matlab and then analysed. As the wavelet function the Symlet 4 was used with major success than other types of wavelets.

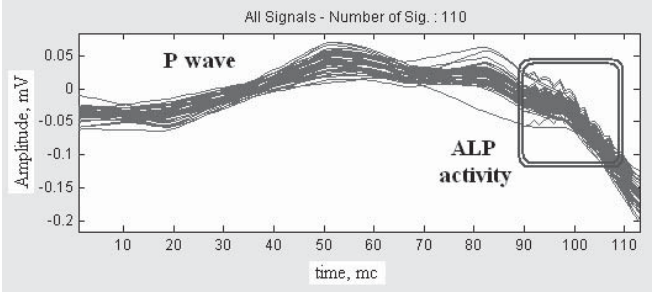

Fig.1 P waves with simulated ALP

By splitting ECG into an approximation part (A5) and detail signals (D1, D2, ..., D5) the wavelet decomposition allowed us to exclude the low-frequency components with high voltage level and investigate only low-amplitude components such as ALP. The results of the discrete wavelet transform are wavelet coefficients C, which are function of frequency band and position. Cluster analysis of these coefficients could reveal the variety of P wave morphology.

There are particular levels of wavelet decomposition for which the difference between the signals without ALP and signals including ALP is the most evident. Examinations with ECG of both types confirmed that the wavelet detail signals contain ALP information, which is the part of ECG high-frequency content. D1 and D2 detail decomposition levels are particularly appropriate to ALP detection. High classification accuracy of normal P waves and P waves including low amplitude ALP was reached using K-means clustering algorithm with fixed number of 2 clusters.

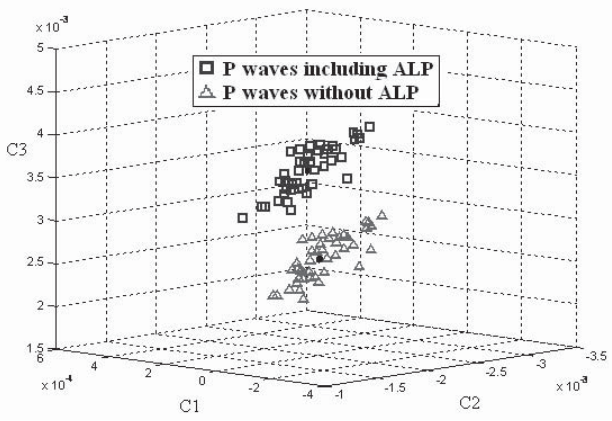

Fig.2 Cluster analysis results

III. CONCLUSION

From experimental results it is evident that values of wavelet coefficients form clusters and make it possible to discriminate between ECG with ALP and ECG without ALP with about 95% correct classifications.

REFERENCES

[1] *Н.Г. Іванушкіна, В.О. Фесечко*. Технології високого розрізнення в електрокардіографії.: Навч.посіб.— К.:НТУУ "КПІ", 2007.—116с.

[2] *Metin Akay (Ed.).* Time-Frequency and Wavelets in Biomedical Signal Processing. IEEE Press, 1997, - 652 pp.

[3] *Абакумов В.Г., Рибін О.І., Сватош Й.* Біомедичні сигнали. Генезис, обробка, моніторинг — Київ, Нора-принт, 2003, — 426с.

[4] *Е.О. Иванько, Н.Г. Иванушкина, Ю.С. Синекоп*. Многоуровневый анализ электрокардиограмм для выявления поздних потенциалов предсердий// Электроника и связь: тематический выпуск "Электроника и нанотехнологии". – 2009.– №4-5.– с.160-164.

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