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METHODS

Wavelet Analysis of Electrocardiograms

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Some electrocardiograms, *e.g.* electrocardiograms recorded in patients with atrial fibrillation, myocardial infarction, or receiving some medications, contain waves of small amplitude. Despite low amplitude, these waves can significantly affect correct identification of the pathological process and diagnosis. The approach proposed by us allows studying these small waves using the wavelet analysis by constructing the corresponding wavelet image of ECG using special software. Two examples of construction of wavelet images of ECG in atrial fibrillation and myocardial infarction are presented.

Key Words: *electrocardiogram; diagnosis; wavelet pattern*

Some ECG, *e.g.* ECG recorded in atrial fibrillation, myocardial infarction, or during treatment with some medications, contain waves of small amplitude. Despite their low amplitude, these waves can significantly affect correct identification of the analyzed process and diagnosis [1,4]. Let us see how these waves in ECG can be analyzed by wavelet analysis used for profound understanding of various processes [2,3].

Brief characteristics of wavelet analysis

To analyze local changes in the signal, we use wavelet described by the function:

$$\Phi(a,b,t)=V_0\left\{\left[\left(\frac{t-b}{a}\right)^2-1\right]\times\exp\left[-0.5\left(\frac{t-b}{a}\right)^2\right]\right\}. \quad \mathbf{(1)}$$

In function (**1**), parameter a determines wavelet width. Wavelet is moved along the time axis t by changing parameter b, which enables correlation analysis of ECG $\Phi(t)$. Correlation function of this process is described by an integral equation:

$$R(a_k,b_k,t)=\int_0^T\Phi(a_k,b_k,t)x(t)dt. \quad \mathbf{(2)}$$

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The scheme of integration algorithm is presented in Figure 1. A computer program created using this algorithm allows us to perform necessary calculations and reveal small waves in the diagram $\Phi(t)$. The calculations are performed within two cycles with discrete changes in parameter a of the wavelet (cycle 1) and parameter b setting wavelet movement along the time axis t (cycle 2). Doing these calculations, we determine the optimal a-b combination corresponding to the maximum of the correlation function. This should simplify the diagnosis.

The program created using the algorithm (Fig. 1) in Mathad environment and allowing creating the wavelet image of the studied process is presented in Figure 2.

Two examples of wavelet images of ECG

We present two examples of creating wavelet images of ECG with waves of low amplitude using the developed program (Fig. 2).

Example 1. A fragment of ECG with small waves recorded during atrial fibrillation and its wavelet image are presented [4] (Fig. 3, *a*).

Example 2. A fragment of ECG with small waves recorded during myocardial infarction (Fig. 3, *b*) and

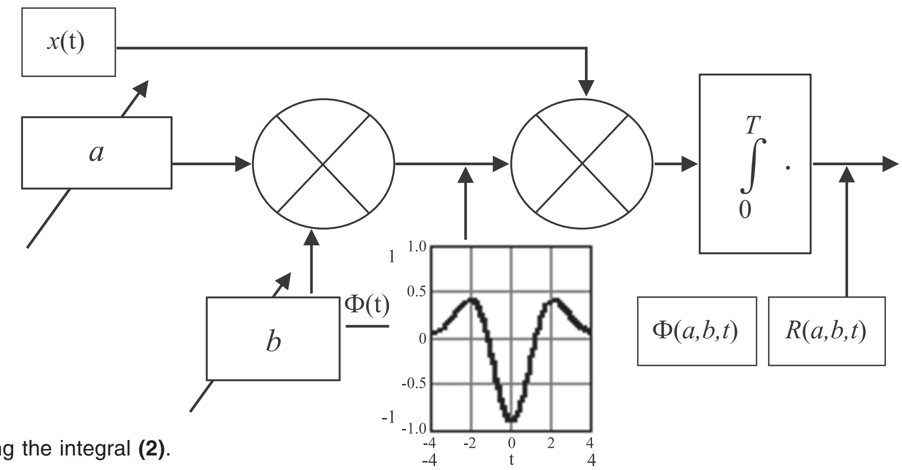

Fig. 1. Scheme of the algorithm for calculating the integral **(2)**.

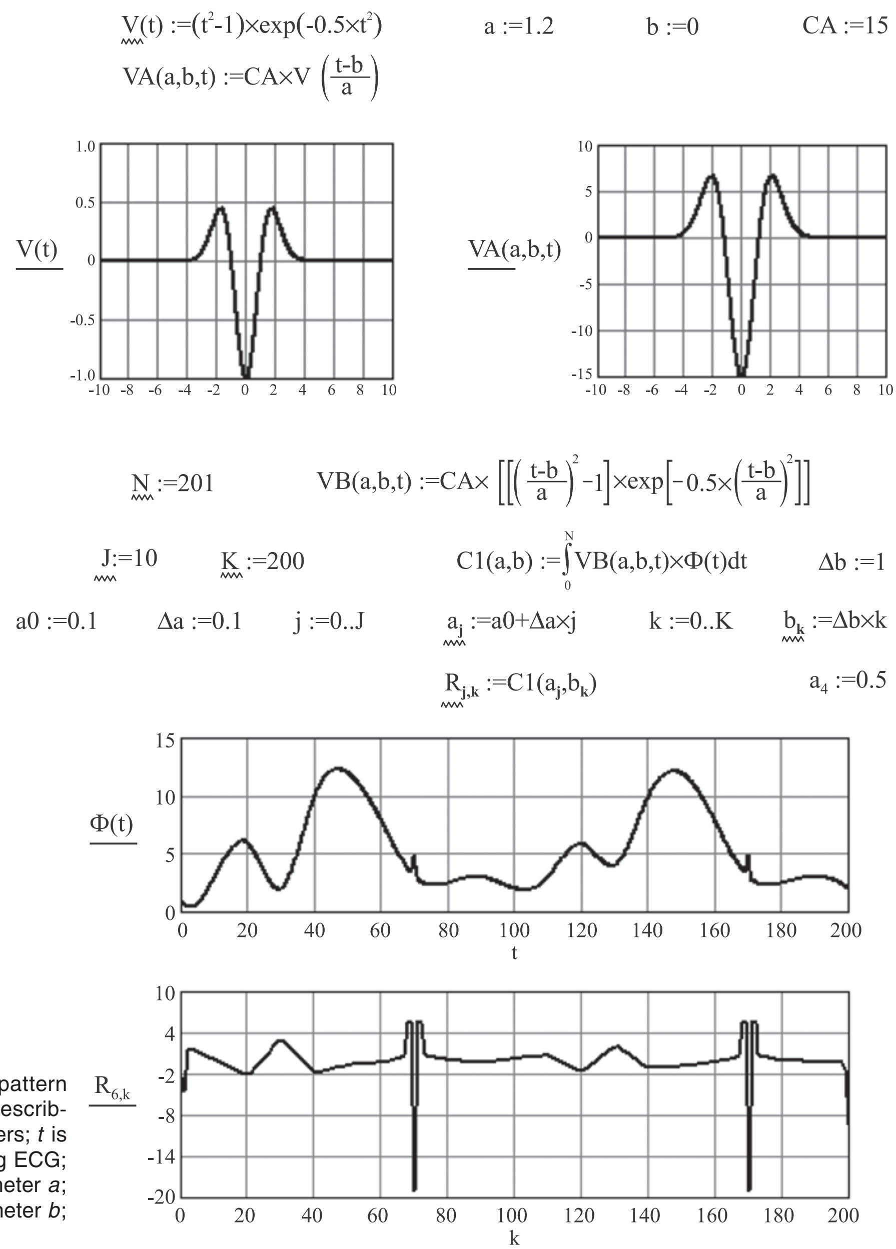

Fig. 2. Software allowing to create wavelet pattern of the study process. *V(a,b,t)* is a function describing the wavelet; *a* and *b* are wavelet parameters; *t* is normalized time; Φ*(t)* is the function describing ECG; *j* is the number of cycles of changes in parameter *a*; *k* is the number of cycles of changes in parameter *b*; $R_{j,k}$ is wavelet image.

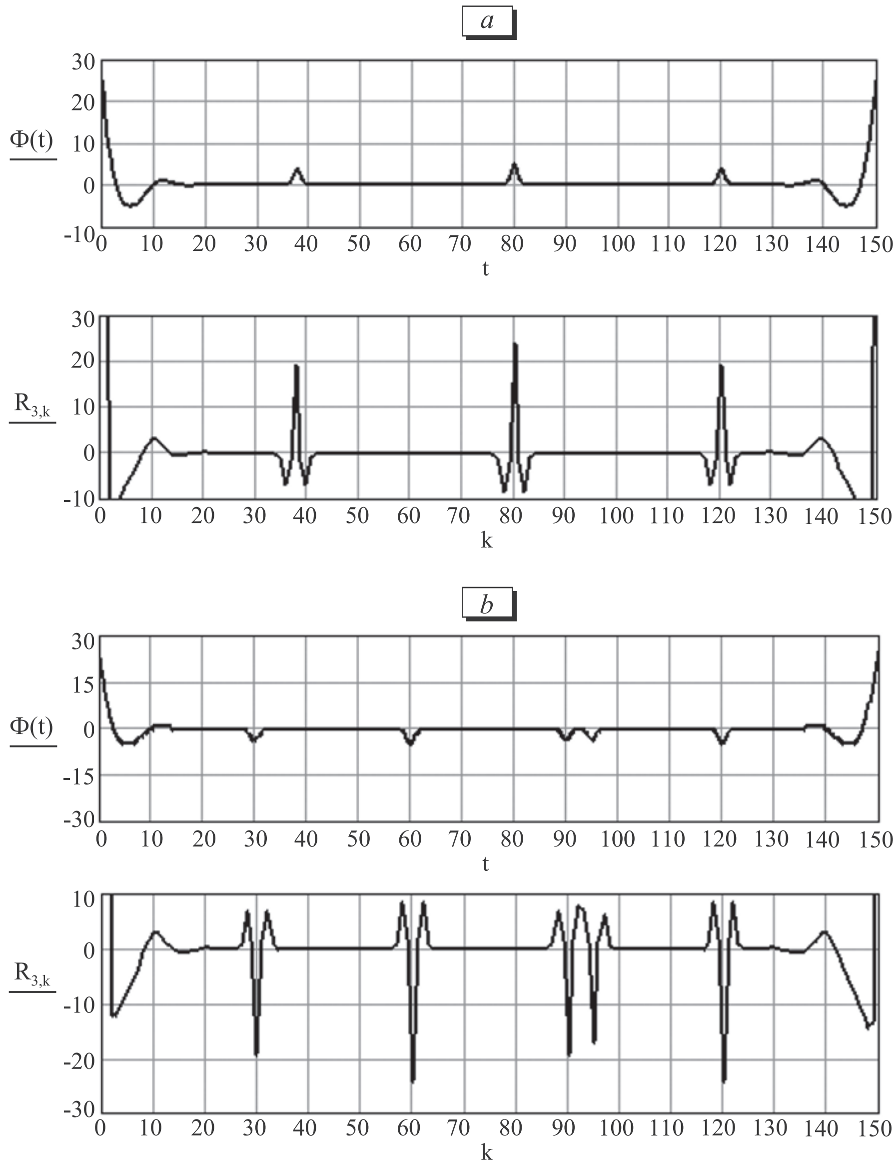

Fig. 3. Fragments of ECG recorded in artrial fibrillation (*a*) and myocardial infarction (*b*).

its wavelet images are presented [1]. The image allows distinguishing the waves and their splitting, which affects correct establishing of diagnosis.

Thus, we propose a method of ECG analysis using computer-assisted wavelet imaging. This analysis is aimed at more precise detection of small waves of ECG affecting the diagnosis. Two examples of creation of wavelet image of ECG in atrial fibrillation and myocardial infarction are presented.

REFERENCES

1. Gordeev IG, Volov NA, Kokorin VA. Electrocardiogram in Myocardial Infarction. Moscow, 2016.
2. Fedoseev GB, Trofimov VI, Negrutsa KV, Timchik VG, Golubeva VI, Aleksandrin VA, Razumovskaya TS, Kryakunov KN. Regarding to the issue of the role of cytokines in the pathogenesis of asthma and the possibilities of anticytokine therapy. Ross. Allergol. Zh. 2016;(6):23-26. Russian.
3. Chui CK. An Introduction to Wavelets. Moscow, 2001. Russian.
4. Ebert HH. Easy ECG: Interpretation: Differential Diagnoses. Moscow, 2010. Russian.