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Analysis of the uterine contractility: wavelet cross-correlation function and wavelet coherence measure

Evaluation of uterine contraction activity is an important element in physiological menstrual cycle and diagnostics of labor. Changes in synchronization of two simultaneously recorded uterine contractility signals accompany various kinds of gynecology disorders and obstetric pathologies, e.g. endometriosis, fibromyomas, preterm birth and tumors. The purpose of this study is to analyze these signals using wavelet cross-correlation function and wavelet coherence measure.

Spontaneous uterine contractions were recorded directly by a dual micro-tip catheter (Millar Instruments, Inc.). The device consisted of two ultra-miniature pressure sensors. The distance between the sensors was 30mm (one sensor was placed in the fundus and the other in the cervix). The sensors produced electrical signals, which varied in direct proportion to the magnitude of measured pressure. We have analyzed the signals obtained during examinations of women suffering from primary dysmenorrhea (28 examinations), endometriosis (11 examinations), uterine myomas (9 examinations), and 1 examination from healthy woman. The Bioethics Committee of Medical University of Białystok approved the study. This method is invasive thus there was no control group.

Wavelet cross-correlation function describes the dependency of correlation of two signals on the shift between them. Location of maximum or minimum of this function informs us about the relative time delay of these signals. Signals are considered similar if the maximum is close to 1 or minimum is close to -1 (inverted signal). We have used multiresolution analysis from wavelet analysis to create wavelet cross-correlation function. We have chosen suitable frequency level, where energy is transferred, as the base for computation of wavelet cross-correlation function. Wavelet coherence measure was calculated by multiresolution wavelet analysis of the uterine contraction signals and a coherence analysis by means of Welch method in selected frequency band containing the dominant frequency. By computation of wavelet coherence function we have obtained the information what are the common frequencies and when they appear. We were also able to estimate the similarity of two signals.

Negative shifts computed by means of wavelet cross-correlation function indicate improper propagation of contractions (wrong direction) in unhealthy women. Using graphs of these functions one can distinguish visually the signals obtained from

healthy woman from signals obtained from unhealthy women. Common frequency for signals from uterine fundus and uterine cervix computed by means of wavelet coherence function is about 0.05Hz. The lowest similarity (synchronization) between signals from uterine fundus and uterine cervix has been observed for signals from women suffering from primary dysmenorrhea.

We concluded that these methods may be useful tools in analyzing synchronization of two simultaneously recorded uterine contraction signals.

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