Assessment of the Gastrointestinal Status by Cutaneous Electrogastrography

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The processing of cutaneous electrogastrogram data by spectral analysis showed high-amplitude spectral activity in normal controls and a shorter high-amplitude period in patients with gastroduodenal ulcers and rectal cancer. In normal subjects and patients, the frequency and time analysis showed differences in the electrical reaction of the gastrointestinal tract after meals. These differences may be useful for noninvasive diagnosis.

Key Words: *gastrointestinal tract; cutaneous electrogastrogram; frequency and time analysis; electrical activity between digestions*

The level of spectral activity in the frequency bands corresponding to stomach, small and large intestine, as well as changes in this parameter are the most informative parameter of the gastrointestinal tract (GIT) status. Since the signal is unstable, for estimation of spectral activity short periods (no longer than 2-3 min), during which the signal can be considered stable, are used. This determines the frequency interval (0.33-0.50 cycles/min) in Fourier's rapid transformation. The entire frequency interval of GIT activity is 0.5-12 cycles/min: 2-4 for the stomach, 8-12 for the small intestine [9], and 4-8 cycles/min for the large intestine [7]. The resolution at which few (sometimes only 3) points for the interval are known is insufficient for analyzing the GIT status. The minimal requirement for the diagnosis is a resolution of 0.1 cycles/min.

We applied the frequency and time analysis to the data of cutaneous electrogastrography (EGG).

MATERIALS AND METHODS

Control group consisted of 40 subjects (27 men and 13 women aged 18-46 years) without gastrointestinal problems. Thirty-five patients with duodenal ulcer at the stage of exacerbation, 11 patients with gastric ulcers (9 of these with complications: decompensated stenosis of the pyloroduodenal area), 10 patients with diphyllobothriasis (parasitic disease), and 4 with sigmoid cancer were examined.

On day 1 the patients were examined after an overnight fast for 3 h, and on day 2 after standard breakfast for 2 h. The patients were examined in the lying position.

For measuring the electrical activity of the GIT, a disposable Ag/AgCl electrode (ARBO) was placed on the abdomen at a distance of 2-3 cm from the navel. The second electrode was fixed to the leg (neutral point). The site of electrode fixation was treated with ethyl alcohol, in men hair was shaven. The scheme of measurements was asymmetrical, in contrast to the symmetrical, when the difference of potentials from two electrodes placed on the stomach projection symmetrically in relation to the neutral point is measured. This scheme is preferable because the symmetrical scheme is fraught with the emergence of "doubled maximum" in assessing the spectral activity. The cause of this phenomenon is not quite clear. It may be due to generation and propagation of electric signals in human body. The signals were recorded by autonomic gastrograph at a discretion frequency of 2 Hz and data input in PC.

Two approaches were used in EGG processing. In the first, 2-3-h long EGG record was divided into intervals of 2-3 min with 10-60 sec shift (with overlapping). Spectral activity for each interval was as-

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sessed by a previously described method. For each frequency interval the leading frequency was determined at which the incidence of maximum spectral activities was the highest. For this frequency, changes in activity were plotted versus time. The leading frequency value is necessary for analysis of the maximum activity, so that local maximum spectral values be disregarded, because their contribution to the pattern of activity distribution by frequencies is negligible.

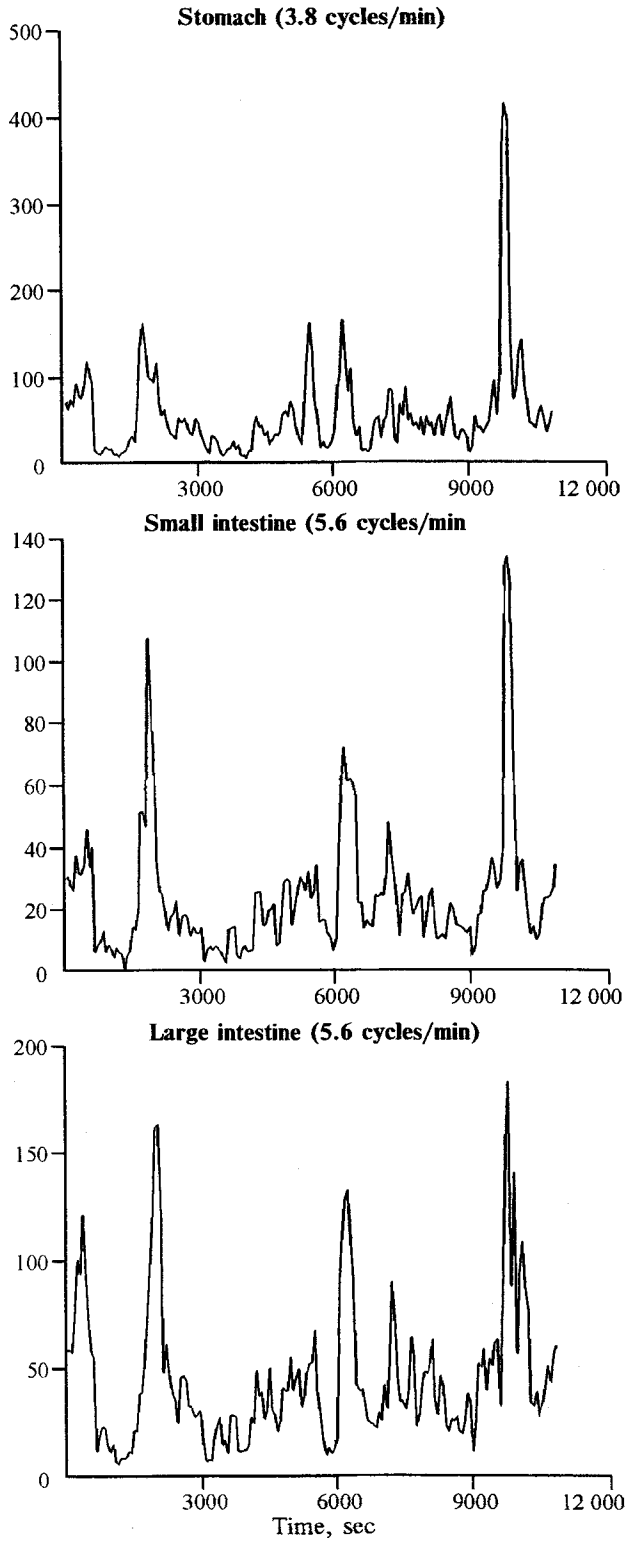

Fig. 1. High-amplitude periodical electrical activity of the gastrointestinal tract in h ealth. Here and in Fig. 2: ordinate: spectral activity, arb. units.

The second method consisted in analysis of the EEG of so-called wavelet transformation [4,5] during the first 10 min after meals. This transformation is similar to Fourier's transformation; in the latter the frequencies are considered, while in our case we considered the characteristic time scales (for approximate evaluation of ν frequencies for characteristic time a, $\nu=1/a$ is taken).

The data were statistically processed using Student's t and χ^2 tests. The differences were considered significant at $p<0.05$.

RESULTS

Time course of changes in spectral activity of signals from the stomach, small and large intestine in health for the leading frequencies in each of the frequency sub-bands (3.8, 5.6, and 10.1 cycles/min) is shown in Fig. 1. Periodical activity outbreaks are 2-3 times higher than the total mean background and virtually simultaneous for all compartments. In the control group this phenomenon was observed in 27 out of 40 subjects (70%). The time between outbreaks was 67±18 min.

In sigmoid cancer, the period of spectral activity of the signals is 15-25 min (Fig. 2). In diphyllobothriasis there were no outbreaks higher than the background activity. In gastroduodenal ulcer the period of outbreaks was shorter than in health (37±14 min).

Assessment of wavelet transformation during the first 10 min after food loading in healthy subjects and in patients with stenosed opening of the stomach and gastric ulcer showed essential differences between the normal status and disease (Fig. 3). In healthy subjects, the signal intensity drops several minutes after food loading, and simultaneously its frequency decreases for 2-3 min (or the characteristic period is prolonged). In disease the activity is continuous or high within a certain band a.

Therefore, the time between consequent flashes of spectral activity of EGG data in the control is significantly higher than in GIT diseases (gastroduodenal ulcers and sigmoid cancer). These flashes do not occur in diphyllobothriasis. By the duration, periods of increased GIT activity in the control are approximating the third phase of the motor complex status between digestions [1]. However, while analyzing GIT contractility, one should remember that

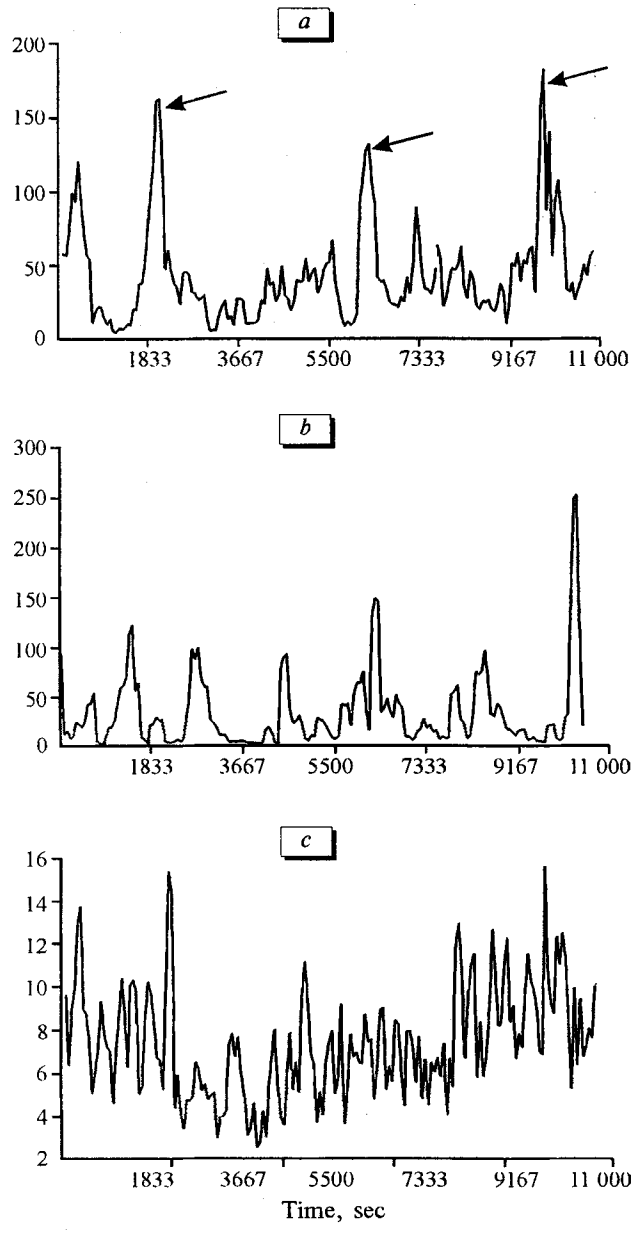

Fig. 2. Changes in electrical activity of the gastrointestinal tract in time in health (*a*), sigmoid cancer (*b*), and diphyllobothriasis (*c*). Leading frequency 5.6 (*a*), 6.2 (*b*), and 7.2 cycles/min (*c*).

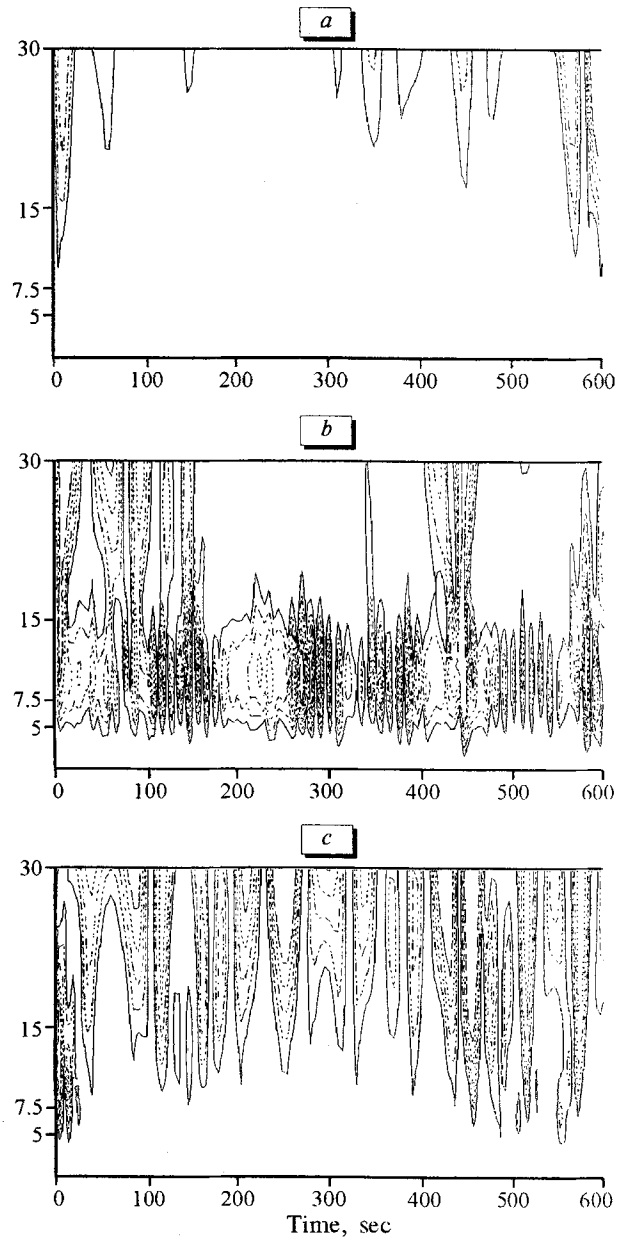

Fig. 3. Differences in the levels of wavelet transformation during the first 10 min after food loading in health (*a*), stenosis of the stomach opening (*b*), and gastric ulcer (*c*). Ordinate: characteristic time scale, sec; a value inverse to scale may be regarded as frequency.

this parameter does not always follow the electrical activity [3]. The relationship between fluctuations in the amplitude of GIT electrical activity and the third phase of motor complex between digestions can be detected by analysis of the correlations of cutaneous EGG and intracavitary pHmetry data and motilin concentration in the blood [1].

A decrease in the period of GIT activity, which was observed in this study, coincides with previous results [2]. The proposed methods provide more accurate parameters and present more values, for instance, the leading frequencies.

A decrease in the frequency and amplitude of EGG during the first 10 min after food loading was reported before [6,8]. Wavelet transformation for EGG data processing demonstrates better the differences in the time course of changes occurring in health and disease during this period than the traditional methods of frequency analysis.

The proposed methods for EGG data processing effectively detect the early stages of GIT diseases. This approach may be useful for detecting GIT abnormalities and their forms by noninvasive methods.

REFERENCES

1. Z. Ito and T. Sekiguchi, in: *Physiology and Pathophysiology of the Gastrointestinal Tract* [in Russian], Ed. by J. M. Polac *et al.*, Moscow (1989).
2. A. A. Kurygin, V. A. Bagaev, Al. A. Kurygin, and L. I. Sysoeva, *Motor Function of the Small Intestine in Health and Some Diseases* [in Russian], St. Petersburg (1994).
3. J. Chen, M. Callum, and R. Richards, *Med. Biol. Eng. Comput.*, **31**, 60-67 (1993).
4. P. Flandrin, in: *Wavelet,* Berlin (1991), pp. 68-98.
5. A. Grossmann, R. Kronland-Martinet, and J. Morlet, *Ibid.*, 2-21.
6. Y. Koneake, Y. Koike, N. Sakurai, *et al.*, *J. Auton. Nerv. Syst.*, **50,** 275-281 (1995).
7. F. Pezzolla, G. Riezzo, M. A. Maselli, and I. Giorgio, *Gastroenterology,* **97,** 313-320 (1989).
8. B. Pfaffenbach, R. J. Adamek, K. Kuhn, and M. Wgener, *Dig. Dis. Sci.*, **40,** No. 7, 1445-1450 (1995).
9. W. O. Richard, L. A. Bradshaw, D. J. Staton, *et al.*, *Ibid.*, **41,** No. 12, 2293-2301 (1996).