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Use of Peripheral Electrography to Evaluate Synchronism of Electrical Activity in Different Parts of the Gastrointestinal Tract

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Use of the technique of peripheral electrography to study electrical activity in various parts of the gastrointestinal tract in dogs after fasting and during digestion is described, and it is shown that a computerized spectral analysis of peripheral electrograms makes it possible to monitor the cycle of fasting periodic gastrointestinal activity. In the process of digestion, the cycle of fasting periodic activity is disrupted and nonadjacent areas of the gastrointestinal tract exhibit synchronous electrical activity.

Key Words: *gastrointestinal tract; migrating myoelectric complex; rhythms; peripheral electrography; spectral analysis*

The recording of electrical activity from the body surface remains problematic. In particular, it is not clear whether the method of peripheral electrography (PEG) can be applied to evaluate peak activity of smooth muscle in the gastrointestinal tract (GIT).

It has been shown that the signal from the GIT recorded with PEG in the low-frequency region carries mainly information about the intensity of peak electrical activity in parts of the GIT [5,6]. Indeed, as indicated by data obtained from intracellular electrodes, the repolarization of a membrane potential in smooth muscle is a fairly long process - taking an amount of time of the order of that of a slow wave (i.e., the total cellular current is not equal to zero). In addition, the action potentials arising at the crests of slow waves are grouped in clusters so that the intensity of their generation in smooth-muscle tissues of the GIT is traceable on the body surface at frequencies equal to basal rhythms of the GIT (0.04-0.35 Hz).

Until now, the periodic activity of the GIT has been studied chiefly by electromyographic methods using implanted electrodes [1,4,8]. The purpose of this study was to evaluate by the noninvasive technique of PEG to what extent the electrical activity in various parts of the GIT is synchronous during fasting periodic activity and in the process of digestion.

MATERIALS AND METHODS

Mongrel dogs of both sexes weighing 15-30 kg were used. In chronic experiments, peripheral electrograms were recorded for 3 h after 18 h of food deprivation and during digestion following the intake of a standard breakfast.

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Measurements were made according to a bipolar scheme, using amplifiers with a pass band of 0.015-0.5 Hz and a sensitivity of 20 to 5000 μV, and nonpolarizable silver-chloride electrodes. A special conducting paste thoroughly moistering both the body surface and the electrode was applied to the electrode surfaces. When such an electrode is placed on the body, a stable galvanic contact with small polarization currents arises, permitting reliable recording in a low-frequency region. The electrodes were taped to previously prepared areas of the right fore and hind paws. The standard grounding electrode was fixed on the left hind limb.

For recording the parameters under study and inputting information to the computer, a multichannel analog-digital system was used, with units that ensured inertia-free recording of signals by a graphic recorder on paper 200 mm wide, as well as display, transformation and computer recording of information. The frequency of digitalization was 5 Hz.

Every portion of the GIT functions within a particular frequency band [2,3] and has its own proximodistal frequency gradient. In the frequency band corresponding to the part of the GIT under study, the total energy of oscillations can be estimated through spectral analysis. Mathematical modeling has shown [7] that the spectra involved are peak spectra, i.e., a peaklike rise in the energy of the spectrum is observed in the particular frequency band characteristic of a given part of the GIT. For this reason, Fourier transform algorithms allowing energy spectra of peripheral GIT electrograms to be obtained were chosen for processing PEG signals (Fig. 1). The data obtained were presented as tables of numerical values of the total energy of the spectrum concerned, in the frequency band corresponding to the part of the GIT under study. This energy was expressed in effective voltages (mV).

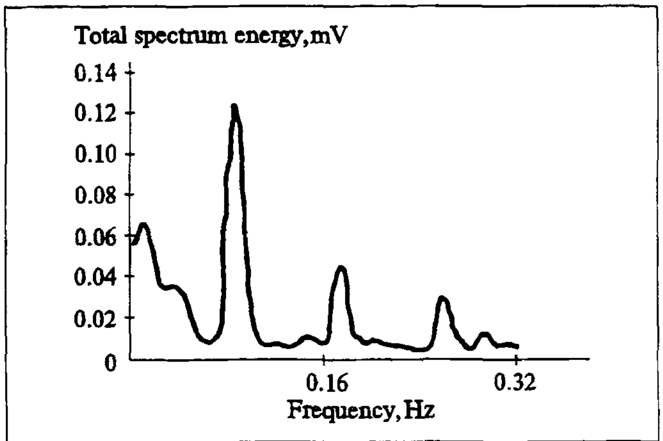

Fig. 1. Spectrum of the signal of a peripheral electrogram taken in one dog after 18 h of food deprivation.

RESULTS

The computerized processing of each peripheral electrogram by the method of spectral analysis demonstrated a cyclic organization of the recorded potentials. In the frequency range of the basal electrical rhythm (BER) exhibited by the stomach (0.05-0.10 Hz), duodenum (0.30-0.32 Hz), jejunum (0.27-0.29 Hz), and ileum (0.23-0.26 Hz), the values of spectrum energy varied with a periodicity equal to one cycle of fasting activity which lasted 71±10 min.

The observed cycles consisted of two phases - one of rest and one of activity, 50±7 min and 21±3 min in duration, respectively. For these phases, the values of spectrum energy in the region of BER frequencies were computed for each of the four GIT parts under study. The values for the stomach proved to be much higher than those

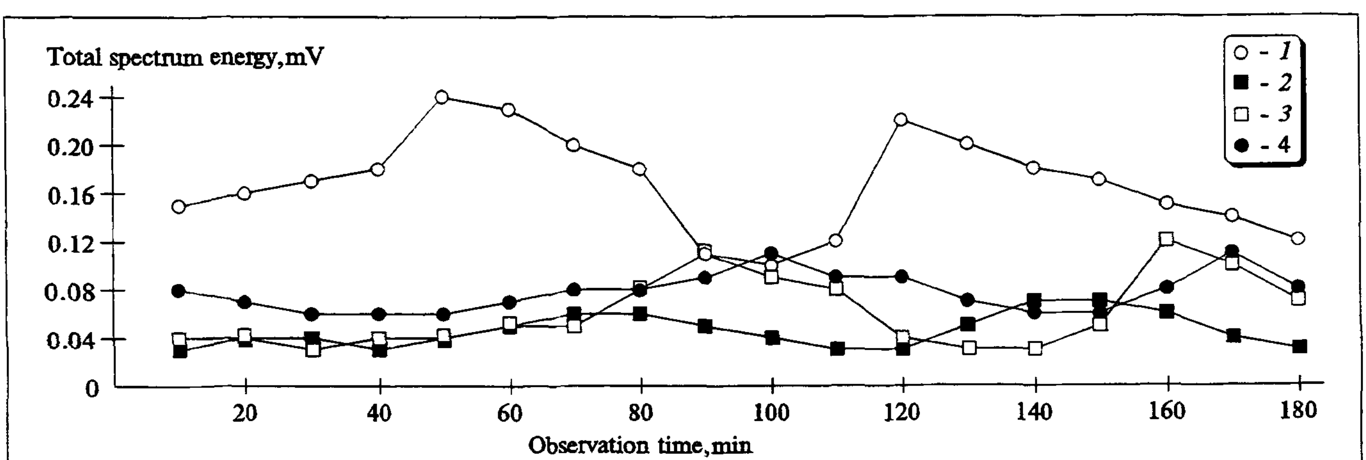

Fig. 2. Plots of spectrum energy values against time obtained for different parts of the gastrointestinal tract through processing of a peripheral electrogram taken in one dog deprived of food for 18 h. *1*) stomach; *2*) duodenum; *3*) jejunum; *4*) ileum.

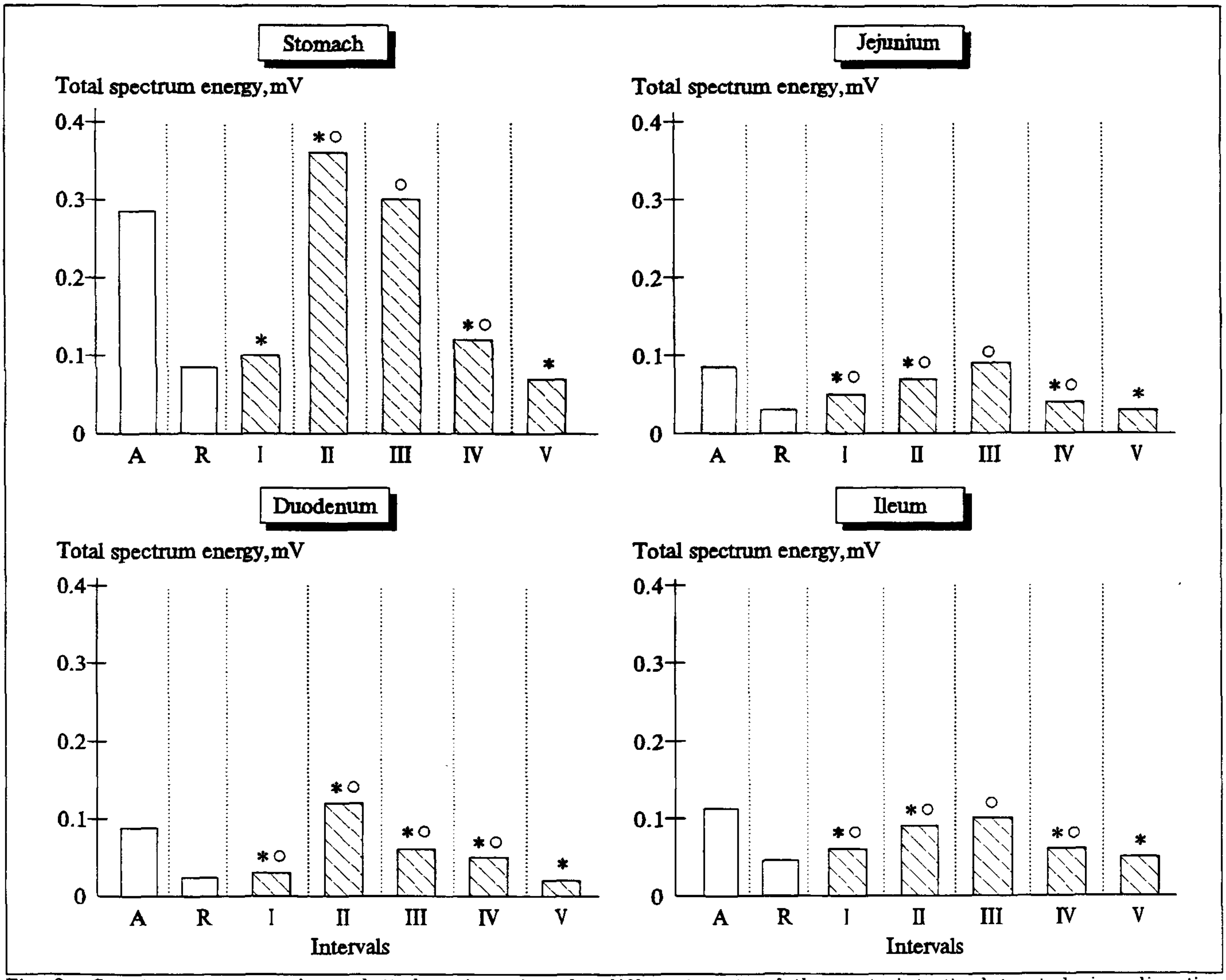

Fig. 3. Spectrum energy values plotted against time for different parts of the gastrointestinal tract during digestion (mean data for 8 dogs). *A*: activity phase; *R*: resting phase. *°$p<0.05$ in comparison with the activity phase (*) and the resting phase (°).

for the duodenum, jejunum, and ileum, probably because the stomach, possessing a greater and more concentrated muscle mass than the spatially extended small intestine, has a stronger electric field.

When plots relating spectrum energy values to time were constructed for each part of the GIT, it was found that the activity phases shift with time toward the distal parts of the digestive tract (Fig. 2). When one of the parts was active, the others were in a resting state. As soon as the activity phase ended in the ileum, increased spectrum energy values were obtained for the BER frequency region of the stomach, and the cycle was then repeated.

Spectrum energy values for each part of the GIT during digestion were then calculated from PEG data and plotted against time (Fig. 3).

Immediately after the beginning of feeding, electrical activity fell sharply in all parts of the GIT - interval I in Fig. 3, which lasted 3-6 min and was succeeded by interval II of gastric activity, lasting 65-75 min. In the middle of this interval, the spectrum energy values in the duodenal BER frequency range increased considerably and remained high until its end, while the spectrum energy values obtained for the jejunum and ileum were significantly lower than during the activity phase of fasting periodic activity. In interval III (50-60 min), the spectrum energy values in the jejunal and ileal BER frequency ranges increased and were virtually the same as in the activity phase; the spectrum energy values for the stomach remained high, while those for the duodenum tended to decrease but were significantly higher than in the resting phase. In interval IV (40-50 min), lowered spectrum energy values were obtained for all four parts of the GIT, although they remained significantly higher than in the resting phase. In the fifth and last interval of observation (30-50 min), the spectrum energy values recorded for all parts of the GIT were similar to those during the resting phase of fasting periodic activity.

The results of this study indicate that potentials recorded from the body surface with peripheral electrography in the BER frequency ranges of different portions of the GIT reflect the periodic myoelectrical activity of gastrointestinal smooth muscle. An increase in spectrum energy in the BER frequency range of a given part of the GIT corresponds to the passage through that part of a migrating myoelectrical complex. The recorded presence of only one active complex in the digestive tract during a cycle of fasting periodic activity agrees with the data obtained with electromyography from implanted electrodes [1,8]. The main difference of motor activity during digestion from that during fasting consists in synchronous increases of electrical activity in nonadjacent portions of the GIT.

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