ONCOLOGY

Spontaneous Activity of the Stomach and Large Intestine in Healthy Individuals and Patients with Tumors before and after Gastrectomy and Colectomy

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We studied the distribution of main frequencies of spontaneous activity (in the range of 2-4 cycles/min) of the stomach and large intestine in healthy individuals and patients with stomach and colon cancer before and after gastrectomy and resection or total colectomy. The rhythm was recorded noninvasively (from body surface) with Ag/AgCl electrodes connected to a 3-channel portable electrogastrograph. We determined general peculiarities of rhythm formation in the stomach and large intestine in healthy individuals on an empty stomach and after mixed feeding and evaluated changes in spontaneous activity in patients with stomach and colon cancer before and after gastrectomy, resection, or total colectomy. Rhythmic activity of the stomach was coordinated with that of the large intestine in healthy individuals, but not in patients with tumors before the start of specific therapy. Multichannel cutaneous electrogastroenterography and recording of spontaneous electrical activity in the epigastric and perianal regions reflect functional relationships between the stomach and large intestine.

Key Words: *electrogastroenterography; spontaneous activity; stomach cancer; cancer of the large intestine; gastrectomy; colectomy*

Electrogastroenterography (EGEG) is a noninvasive method for recording spontaneous electrical activity of the stomach and small and large intestine from the human body surface [2]. Due to introduction of computer techniques, the method of EGEG is widely used in clinical practice from the early 1990s [4].

Main frequencies of the gastrointestinal tract (GIT) recorded from the body surface are identical to slow wave frequencies measured with electrodes fixed on the stomach and small and large intestine [6]. The relative increase in EGEG amplitude is related to an increase in the amplitude of contractions in GIT organs [5]. The range of 2-4 cycles/min includes frequencies of spontaneous electrical activity of the stomach and large intestine [8,9]. M. A. Amaris *et al*. using multichannel EGEG recording determined the mean frequency of spontaneous electrical activity of the stomach and ascending and descending colon in healthy individuals and patients after gastrectomy and total colectomy [1]. The method of multichannel EGEG allows evaluation of coordination or discoordination of slow waves in the distal and proximal regions of the stomach [7].

Here we recorded main frequencies of spontaneous rhythm of GIT organs (range 2-4 cycles/min) in healthy individuals and patients with cancer of the stomach and large intestine before and after gastrectomy, resection, and total colectomy in the fasting state and after mixed feeding.

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MATERIALS AND METHODS

We examined 16 patients with stomach cancer (10 men and 6 women). Gastrectomy was performed in 15 patients (9 men and 6 women). Three men and 3 women were examined before and after surgery. Examinations were conducted in the early postoperation period (2-4 weeks) and during follow-up (1-1.5 years). The control group included 10 men and 11 women at the age of 16-35 years with normal state of GIT.

Fifteen patients were examined 1 year or more after resection of the large intestine and colostomy. Total resection of the large intestine and ileostomy were performed in 11 patients.

Spontaneous EGEG was recorded using an EGG-2401 electrogastrograph with 3 independent recording channels and constructed at the N. N. Blokhin Russian Cancer Research Center. The lower and upper transmission bands were 0.01 and 0.30 Hz, respectively. The recording frequency was 2 Hz. The signal was digitized on-line and stored in an electrogastrograph. Electrical activity was measured in a quiet room under conditions approximating those for evaluation of general metabolism. The patient lay on the back and did not sleep, speak, or move.

We used standard disposable Ag/AgCl cardiographic electrodes (Niko). The resistance at the contact between electrodes and skin did not exceed 4 kΩ. EGEG was recorded unipolarly. Active electrodes were placed in the epigastric region above the stomach and in the perianal region to the right and left of the rectum. The reference electrode was localized on the abdomen 10-15 cm to the right of the navel. The patients were examined in the morning after sleep. Recordings were performed in the fasting state (60 min) and after mixed feeding (standard hospital breakfast, 950 kcal, 60 min).

The data were input to an IBM 586 computer via a serial port RS 232 and the results of recording in the fasting state and after feeding were organized into 2 text files using special software. The data were subjected to spectral analysis.

The frequency of GIT rhythm characterized by maximum percentage in the range of 2-4 cycles/min was considered as the main frequency. Frequencies were measured at 0.2-cycles/min intervals. The sum of frequencies in a specified interval was 100%.

For each group the total distribution of main frequencies in the epigastric and perianal regions recorded in the fasting state and after mixed feeding was evaluated.

RESULTS

In fasting healthy individuals the frequencies 2.8 and 3.0 cycles/min accounted for 40.0 and 36.8%, respectively (Fig. 1). The frequencies 2.6 and 3.2 accounted for 14 and 6.4%, 2.4 and 3.4 cycles/min for 1.6 % each. Frequencies 2.2 and 3.6 cycles/min were absent. After mixed feeding the frequency 3.2 cycles/min accounted for 51.2%, while the percentage of frequency 3.0 cycles/min decreased from 36.8 to 28.8%. At the same time new frequencies 3.4 (17.6%) and 3.6 cycles/min (3.2%) were recorded.

Thus, in the range of 2-4 cycles/min in healthy individuals after mixed feeding the frequencies of electrical activity were >3 cycles/min and the maximum corresponded to the frequency of 3.2 cycles/min.

In fasting patients with stomach cancer the main frequencies varied from 2.2 to 3.2 cycles/min (Fig. 2, *a*). The frequency 3.4 cycles/min accounted for 4%. Frequency 3.6 cycles/min was not detected. Mixed feeding led to an increase in the percentage of frequency 2.8 cycles/min and a decrease in the percentage of other main frequencies.

After gastrectomy in fasting patients with stomach cancer the main frequencies of electrical activity were 2.2, 2.4, 2.6, 2.8, and 3.0 cycles/min (Fig. 2, *b*). After mixed feeding frequencies 3.4 and 3.6 cycles/min appeared. However, the frequencies 3.0, 3.2, and 3.4 cycles/min constituted <3.2%. The contribution of frequencies 2.2 (25.6%) and 2.8 cycles/min (30.4%) was maximum in the fasting state and after mixed feeding, respectively.

In fasting patients with colon cancer the main frequencies were 2.2, 2.4, 2.6, 2.8, 3.0, and 3.2 cycles/min (Fig. 2, *c*). The contribution of frequency 2.8 cycles/min was maximum (28.6%). The frequencies 3.4 and 3.6 cycles/min contributed <3%. The contribution of frequencies 2.4, 3.2, 3.4, and 3.6 cycles/min increased after mixed feeding. The maximum ratio of frequency 3.2 cycles/min was 30.8%.

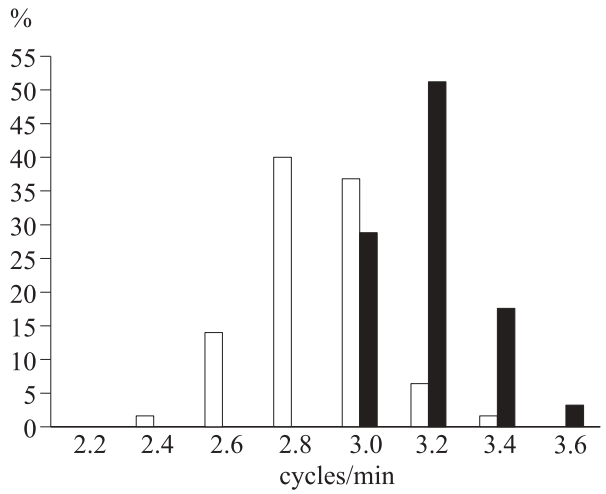

Fig. 1. Distribution of main frequencies in the stomach and large intestine of healthy individuals. Here and in Figs. 2 and 3: abscissa, main frequencies in the range of 2-4 cycles/min; ordinate, ratio of main frequencies (%). Light bars: fasting state. Dark bars: feeding.

In fasting patients with colostomy the main frequencies varied in the range of 2-4 cycles/min. Frequencies 2.8, 3.0, 3.2, 3.4, and 3.6 cycles/min were recorded after mixed feeding (Fig. 2, *d*). The ratio of frequency 3.0 cycles/min was maximum (30%) before and after feeding.

In the fasting state and after mixed feeding the patients subjected to total colectomy had the following main frequencies 2.2, 2.4, 2.6, 2.8, 3.0, and 3.2 cycles/min (Fig. 3). Frequency 3.4 cycles/min was absent before and after feeding. Frequency 3.6 cycles/min was revealed only after feeding (11.1%). The ratio of frequencies 2.6 (25.2%) and 2.2 cycles/min (21.6%) was maximum in the fasting state and after feeding, respectively.

The main frequencies of spontaneous rhythm of GIT in healthy individuals in the fasting state and after mixed feeding in the range of 2-4 cycles/min did not overlap. Mixed feeding improves coordination of rhythms in the epigastric and perianal region and increases the main frequency and its maximum percentage. This increase in the frequency after mixed feeding probably represents the optimal chronotropic effect in healthy individuals that induces strong peristaltic waves moving the stomach content into the duodenum. These results are consistent with the data obtained during artificial stimulation of the stomach during gastroparesis. The increase in the frequency of stimulation by 10% (compared to the main frequency of spontaneous rhythm in the stomach) leads to the appearance of slow peristaltic waves with maximum amplitude [10].

The overlap of the main frequencies before and after feeding and the decrease in the frequency and its maximum percentage in patients with stomach and colon cancer are probably determined by disturbed functional relationships between these organs. Dilation of the large intestine modulates spontaneous rhythm and strength of stomach contractions [11]. Moreover, the stomach coordinates rhythmic activity: proximal regions with high frequency of spontaneous activity

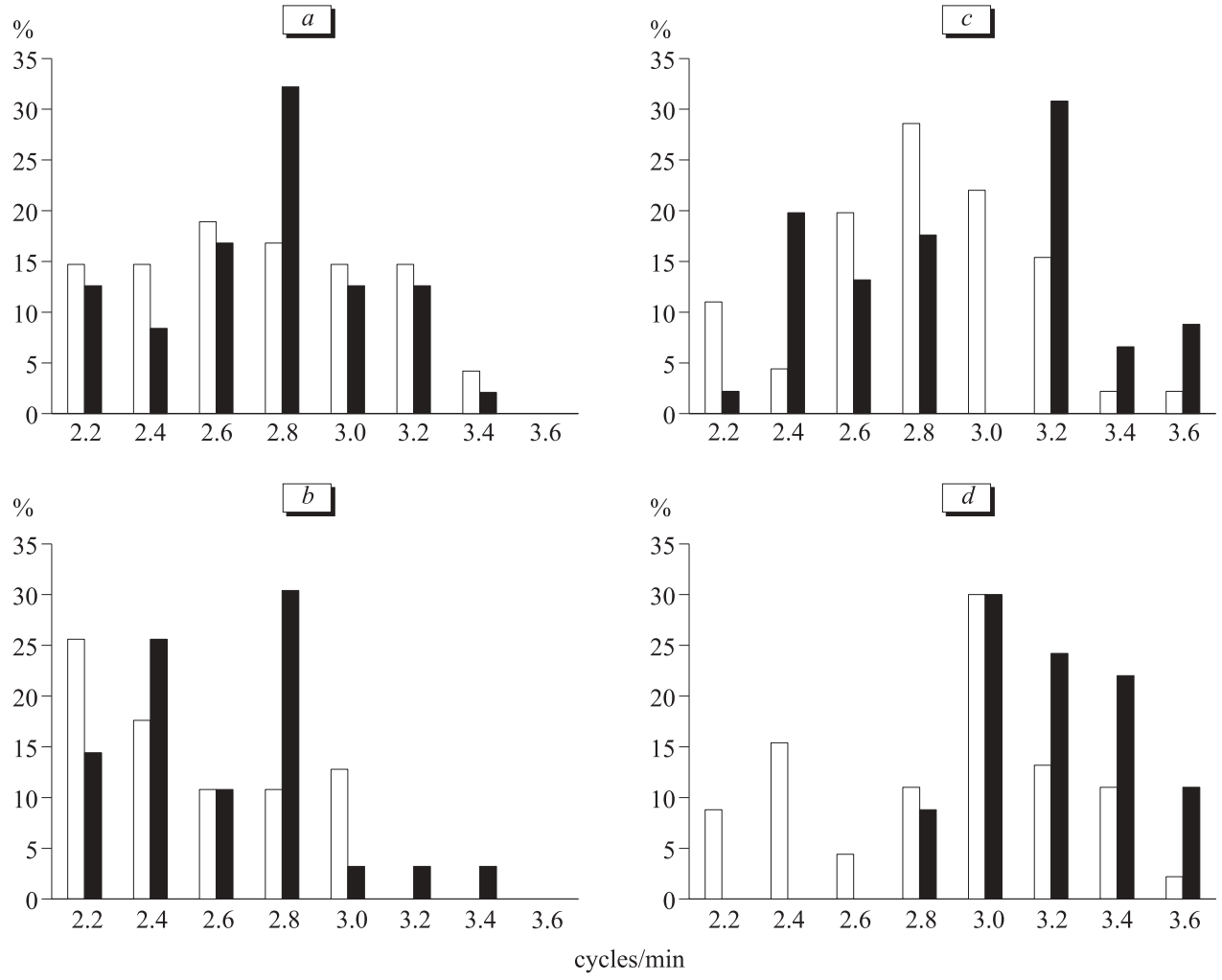

Fig. 2. Distribution of main frequencies in the stomach and large intestine of patients with cancer of the stomach (*a*), gastrectomy (*b*), cancer of the large intestine (*c*), and colectomy (*d*).

determine the rhythm in distal regions with low frequency of spontaneous rhythm [7].

In patients with colostomy we observed an incomplete overlap between the main frequencies before and after feeding, the frequency of spontaneous rhythm in these patients did not increase after feeding as it did in healthy individuals [3]. Gastrectomy and total colectomy did not recover coordination of electrical activity in the epigastric and perianal regions, but reduced the value and maximum percentage of main frequencies.

The distribution of main frequencies of spontaneous rhythm of GIT organs recorded in the epigastric and perianal regions using noninvasive EGEG (range 2-4 cycles/min) reflects coordination of spontaneous rhythm in the stomach and large intestine determining functional relationships between these organs.

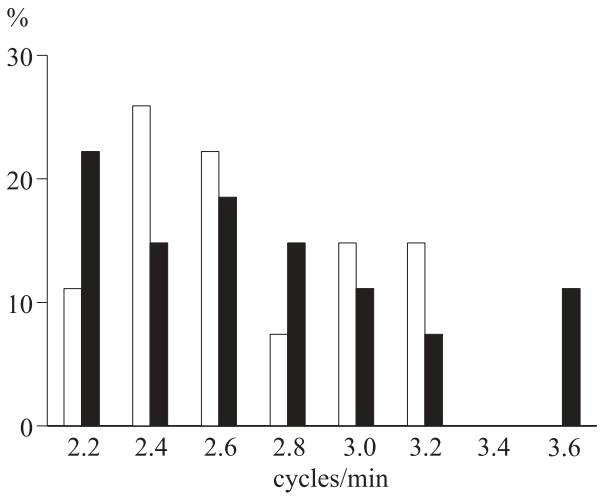

Fig. 3. Distribution of main frequencies in the stomach and large intestine of patients with ileostomy.

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