# Organization of Spontaneous Rhythm of the Small Intestine in Healthy Individuals and Patients with Stomach and Colorectal Cancer

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The distribution of the main frequencies of spontaneous rhythm of the small intestine in the 12.0-8.0 cycle/min range (by the aboral frequency gradient) was studied by the electrogastroenterographic method in healthy individuals and patients with stomach and colorectal cancer before and after gastrectomy and total removal of the large intestine. Organization of spontaneous rhythm of the small intestine on an empty stomach and after mixed food load in healthy individuals and changes in this organization in patients with stomach and colorectal cancer before and after total gastrectomy and complete removal of the large intestine were evaluated. The authors hypothesize that the stomach normally coordinates the small intestinal rhythm, while in stomach cancer this coordination is impaired. Changes in spontaneous rhythm of the small intestine (both in the proximal and distal portions) were detected in patients with colorectal cancer.

**Key Words:** *electrogastroenterography; spontaneous rhythm; small intestine; stomach cancer; colorectal cancer*

Spontaneous contractions of rings from different portions of rabbit small intestine were described for the first time by W. C. Alvarez in 1914; the scientist detected a proximodistal descending gradient of the small intestinal frequencies. In humans the frequency of spontaneous contractions of the duodenum is 11 cycle/min, in the ileac area 8 cycle/min [5,6]. Hence, the range of 8-12 cycle/min includes spontaneous rhythms of the small intestine [7]. J. D. Chen *et al.* reported that the frequencies of spontaneous electrical activity of the small intestine recorded from human body surface and serous membrane coincided [4]. According to their data, spontaneous rhythm of the small intestine on an empty stomach varies from 9 to 12 cycle/min. From this moment supracutaneous electrogastrogram (EGG) us used as a noninvasive electrogastroenterogram (EGEG).

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When studying the distribution of the main frequencies of spontaneous rhythm of the gastrointestinal tract (GIT) in the range of 2-4 cycle/min, we showed that this presentation of the data helps quantitatively evaluate the composition of the main frequencies in the normal range of humans and changes in this range in cancer patients [2]. This paper presents new data of this study: distribution of the main frequencies of the small intestine in the 12-8 cycle/min range.

We studied organization of spontaneous rhythm of the small intestine in healthy individuals and patients with stomach and colorectal cancer before and after gastrectomy and total colectomy, after overnight fasting, and after mixed food load.

## MATERIALS AND METHODS

Sixteen patients with stomach cancer (10 men and 6 women) and 21 healthy individuals (10 men and 11 women, control group) were examined. Fifteen patients (9 men and 6 women) were observed after

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gastrectomy for stomach cancer; of these, 3 men and 3 women, were examined before and after surgery. The studies were carried out in early (2-4 weeks) and in delayed period (1-1.5 years) after surgery.

Seven patients (4 men aged 33-51 years and 3 women aged 30-48 years) were examined 2-5 years after total removal of the colon.

Spontaneous EGEG was recorded by EGG-2401 electrogastrographer developed at Cancer Research Center. The device has 3 independent registration channels. The lower band of frequencies recorded is 0.01 Hz, the upper 0.3 Hz. The frequency of the signal measurement corresponded to 2 Hz. The signal was digitized in the real time mode and retained in the electrogastrographer memory. The examinee lay quietly on the back without sleeping, talking, or moving.

Standard Ag/AgCl disposable electrodes (Niko) were used. The resistance of electrode contact with the skin was no higher than 4 kΩ. EGEG was recorded in a monopolar mode. Active electrodes were placed in the epigastral area above the stomach and perianal area to the right and left from the rectum. Common indifferent electrode was placed on the abdomen, at a distance of 10-15 cm from the navel. All procedures were carried out after night sleeping: after overnight fasting and after mixed food load (standard breakfast, 950 kcal).

The data were transferred from electrogastrographer via optical connection through the RS 232 consecutive port of IBM 586 computer. The data were presented as 2 text files using special software: one file corresponded to registration after overnight fasting, the other to that after test meal. Spectral analysis of the data was carried out [3]. The frequencies were measured with an interval of 0.2 cycle/min; the sum of all frequencies in the selected band was 100%.

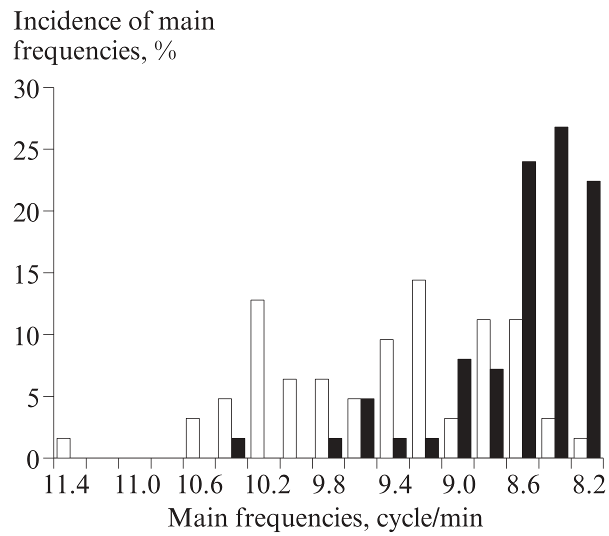


**Fig. 1.** Distribution of the main frequencies of the small intestine in the 12.0-8.0 cycle/min range in healthy individuals after overnight fasting (light bars) and after test meal (dark bars).

The frequency most incident in the 12-8 cycle/min band (by the descending gradient of the small intestine) was taken for the main in each study.

Summary distribution of the main frequencies in the epigastral and perianal areas after overnight fasting and after mixed test meal was plotted for each group.

## RESULTS

All frequencies in the 10.6-8.2 cycle/min band were present in the epigastral and perianal areas of healthy individuals after overnight fasting (Fig. 1), but their incidence was different. Two peaks at 10.2 and 9.2 cycle-min (12.8 and 14.4% incidence, respectively) and paired 8.8 and 8.6 cycle/min frequencies (the incidence of each being 11.2%) were distinguished. The

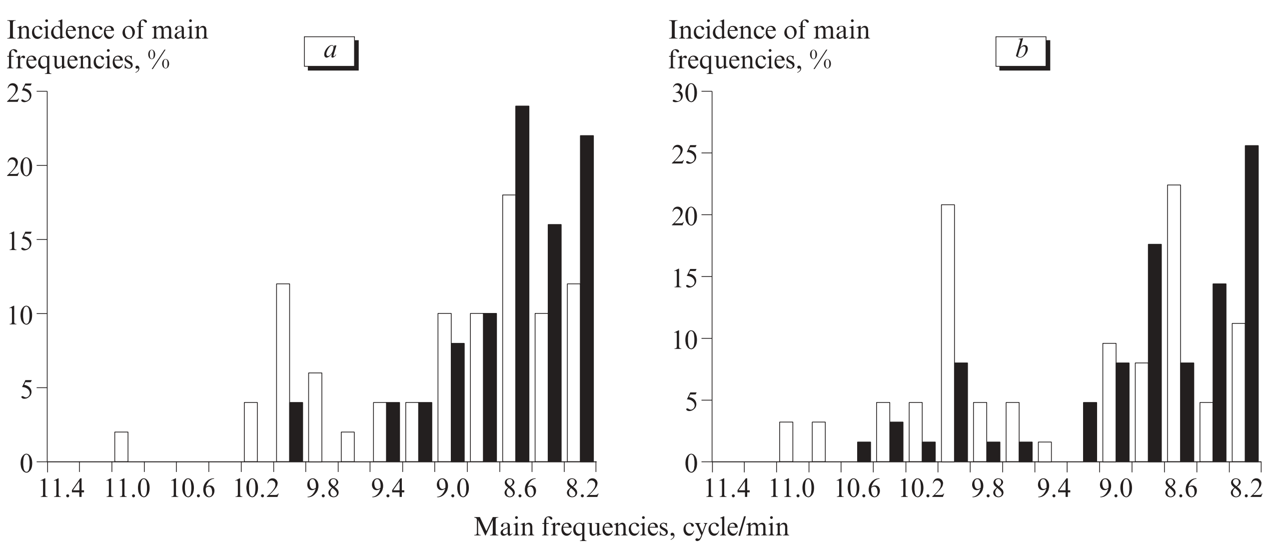


**Fig. 2.** Distribution of the main frequencies of the small intestine in the 12.0-8.0 cycle/min range in stomach cancer (*a*) and after gastrectomy (*b*).

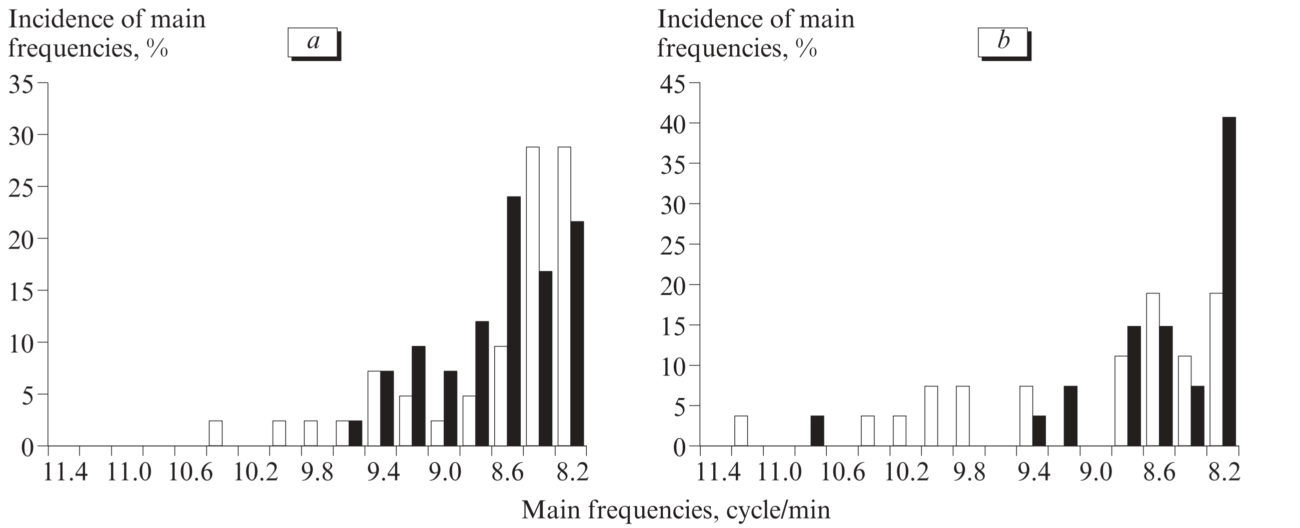


**Fig. 3.** Distribution of the main frequencies of the small intestine in the 12.0-8.0 cycle/min range in colorectal cancer (*a*) and after total colectomy (*b*).

incidence of 8.6, 8.4, and 8.2 cycle/min sharply increased after mixed food load (27.2, 28.8, and 19.2%, respectively), their summary incidence reaching 76.2%.

In patients with stomach cancer examined after overnight fasting the distribution of the main frequencies had two peaks at 10.0 and 8.6 cycle/min frequencies (incidence 12 and 18%, respectively; Fig. 2, *a*). After meals the summary incidence at frequencies of 8.6, 8.4, and 8.2 cycle/min was 62%, which was 14.2% lower than in the controls. After gastrectomy the incidence of 10.0 and 8.6 cycle/min frequencies increased to 20.8 and 22.4%, respectively, after overnight fasting, while after mixed test meals the summary incidence of frequencies 8.6, 8.4, and 8.2 cycle/min decreased to 48.0% (Fig. 2, *b*).

In colorectal cancer, the incidence of frequencies 10.0-10.2 cycle/min did not exceed 3%, while for frequencies 8.4 and 8.2 cycle/min it increased to 28.8% after overnight fasting (Fig. 3, *a*), and after mixed food load the summary incidence at frequencies 8.6, 8.4, and 8.2 cycle/min was virtually the same as in stomach cancer (62.4%).

Two peaks at frequencies 8.4 and 8.2 cycle/min (26% incidence both; Fig. 3, *b*) were recorded after overnight fasting in patients with total colon resection. After meals the summary incidence of frequencies 8.6, 8.4, and 8.2 cycle/min (62.9%) in these patients virtually did not differ from that in stomach cancer, while the incidence of 8.2 cycle/min frequency was 40.7%.

Three peaks of the main frequencies (10.2, 9.2, 8.8, 8.6 cycle/min) were detected in the small intestine of healthy individuals after overnight fasting in the 12.0-8.0 cycle/min range of spontaneous rhythm, measured simultaneously in the epigastral and perianal areas. Mixed food load induced an increase in the incidence of the main frequencies (8.6, 8.4, and 8.2 cycle/min), which corresponded to propagation of the peristaltic wave from the proximal portion of the small intestine to the distal portion, by the aboral frequency gradient. In stomach cancer patients the incidence of the main frequency (10 cycle/min) after overnight fasting (12%) was virtually the same as in the control, but its second peak in an intact stomach (9.2 cycle/min frequency) was shifted towards the distal portion of the small intestine (8.6 cycle/min). After mixed meals the incidence of the main frequencies in the distal portion of the small intestine was lowered in comparison with the control.

After gastrectomy the incidence of the main frequencies in the peak areas (10.0 and 8.6 cycle/min frequencies) after overnight fasting increased, while the summary incidence of the main frequencies in the distal portion of the small intestine decreased still more, and the time course of their incidence in the 8.6-8.2 cycle/min range changed in favor of the 8.2 cycle/min frequency (25.6%). These results suggest that gastric and small intestinal rhythms are coordinated. It seems that normally the stomach is responsible for even distribution of the small intestinal rhythm both after fasting and mixed food load. Resection of the stomach leads to a sharp activation of the small intestinal pacemakers.

In contrast to stomach cancer, colorectal cancer is associated with complete suppression of rhythms in the proximal portions and enhanced pacemaker activity in the distal portions of the small intestine after overnight fasting. Mixed food load does not increase the incidence of the main frequencies. Pacemaker activity of the proximal portions of the small intestine is absent after fasting in colectomied patients, while the reaction to food load is expressed as sharp asymmetry of the main frequencies in the distal portions of the small intestine.

The ratios detected in our study in patients with colorectal cancer are in line with the main law of reflex regulation of the GIT motor function, according to which the peristalsis of the stomach and proximal portions of the small intestine is suppressed in colorectal disease [1,8]. Hence, noninvasive registration of the small intestine spontaneous rhythm organization is an informative indicator of its function.

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