AN EXPERIMENTAL METHOD FOR ELECTROGRAPHICALLY DETERMINING THE MOTILITY OF THE DUODENUM DURING DIGESTION

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(Received April 23, 1958. Presented by Active Member AMN SSSR V. N. Chernigovskii)

The secretory, excretory and motor functions of the gastrointestinal tract have been extensively studied in the laboratories of I. P. Razenkov. M. A. Sobakin used the electrographic method in his detailed study [2] of the motility of the small intestine wall in chronic experiments. We used the electroenterographic method simultaneously with the kymographic method to examine the motility of the duodenum during both physiologic hunger and digestion.

The problem concerning the parallel comparison of the electric and mechanical activity of the small intestine has been very inadequately treated in the literature. What works there are on this subject have been for the most part conducted under conditions of acute experiments or on isolated preparations of the small intestine (E. R. Mogilevskii, 1944; Berkson, 1933; Bozler, 1939; W. C. Alvarez and Mahoney, 1922; C. B. Puestow, 1932-1933; B. I. Hasama, 1934, et al.). The material obtained by these authors indicates that the rhythms of the electric and mechanical activity of the intestinal wall are coincidental. The first attempt in world literature to study the electric phenomena in the small intestine under conditions of the chronic experiment was that of A. A. Titaev (1943). In his investigations, special attention was given to potential changes connected with the secretory activity of the small intestine wall.

In the absence of chyme, good contact was assured by the method we used for leading off the biological currents from the intestinal mucosa. Electrographic determination of small intestine motility is considerably more difficult in the presence of chyme, because foreign particles of chyme can fall between the electrode and the intestinal wall during the pendular and peristaltic movements, altering the degree of contact and the exactitude of the recording.

For our study of duodenal motility, particularly during digestion, we used the method M. A. Sobakin developed [2] of leading off biological currents from an electrode implanted in the wall of the gastrointestinal tract. Recording was done with a unipolar lead. The biological currents were led off to an ink-writing EGS-1^3 apparatus. The ink recording, in contrast to a photogram, made it possible to observe the rhythmic activity occurring during digestion as it occurred. Under conditions of physiologic hunger, we synchronously recorded on the same tape the electric waves and the motility of the intestine as registered by a balloon-kymograph.

The tape was adjusted to two speeds in order to obtain a more extensive recording.

As the indifferent electrode, we used a bath with a warm physiological solution, with the posterior extremities of the animal submerged in it. The active electrode was a plastmass (methacrylate) fistula placed on the body of the stomach. From this, a multiple-strand wire insulated in vinyl chloride was passed through a large gasket. A platinum loop was welded to the end of this wire. This loop was introduced through a small incision in the seromuscular layer into the duodenal submucosa 4-5 cm below the tip of the pancreas. In order to keep the electrode firmly in the intestinal wall during peristalsis, a gasket was fastened to the implantation

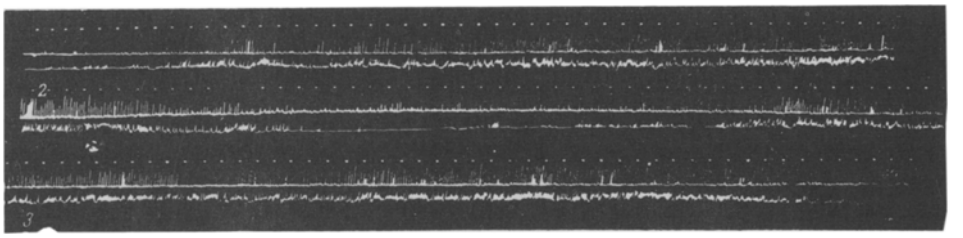

Fig. 1. Synchronous recordings of duodenal motility under conditions of physiologic hunger by electrography (top curve) and by kymography (bottom curve); time is shown in minutes by the dots; the calibration at the end of the recording is 10 mv. Experiment made November 21, 1957 on the dog Laima.

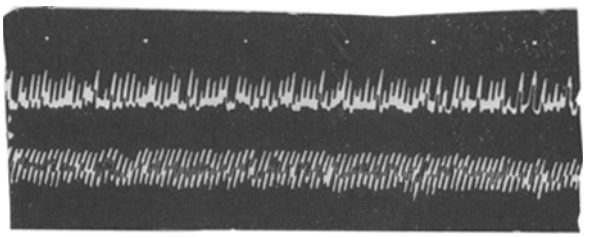

Fig. 2. Synchronous recordings of duodenal motility on high-speed tape under conditions of physiologic hunger. Curves (from top to bottom): time in one minute marks; electroenterogram, electromyogram.

place of the platinum loop.

To avoid the penetration of the platinum loop into the intestinal lumen, a plastmass deflector was attached above the platinum loop on top of the serous membrane of the intestine. The deflector and the platinum loop were fastened to the intestinal wall with ligatures of thin silk.

EXPERIMENTAL RESULTS

Electrodes implanted in this way made it possible to make prolonged and continuous observations in chronic experiments of intestinal motility both during digestion and on an empty stomach. Figure 1 shows a sample of the synchronous electrographic and kymographic recordings of duodenal motility on an empty stomach. As the Figure shows, the electric recording coincided with the mechanical in both the alternation of the "work" and "rest" period and the force and rhythm of the contractions. The "work" period of the duodenum lasted an average of 30-40 minutes. The rhythm of the peristaltic waves was 5 waves per minute, of the pendular movements, 16-18 waves per minute. When the periods of relative "rest" were compared, it was found that the mechanographic method of recording did not give a clear picture of the motor process. Evidently, this method does not reflect all the processes which take place in the intestinal wall at the various periods and with the various forms of its activity. Our electrographic data and the experimental material obtained by E. S. Mogilevskii in acute experiments give reason to propose that the rhythmic processes continue in the intestinal wall as fluctuations of the bioelectric potentials throughout the "rest" period, although no clear contractions are observed during this time.

These rhythms appeared more clearly on the higher-speed tapes (Fig. 2). Figure 2 gives a good illustration of how the rhythm of the electric waves and of the mechanical contractions, 16 waves per minute, i. e. corresponding to the pendular movements, is coincidental. During the whole "work" period, however, no such true conformity was observed, because the electrographic recording method is more sensitive than the mechanographic. For example, we included an electroenterogram made during digestion (Fig. 3). The food stimulus (300 g of bread) was given during a "rest" period, 10 minutes after the termination of a "work" period. After the ingestion of the food stimulus, the amplitudes of the electric waves, and therefore the force of the duodenal contractions, showed a definite variability. The alternation of the groups of higher-amplitude electric waves representing the peristaltic and pendular movements was similarly variable in time. However, as a whole, the electric activity of the duodenal wall is greater during digestion than during the periods of relative "rest" and less than during the "work" periods in conditions of physiologic hunger.

SUMMARY

The author developed a method of leading off the biocurrents from the implanted electrodes. The latter provide the possibility of carrying out prolonged and continuous electrographic examinations of the

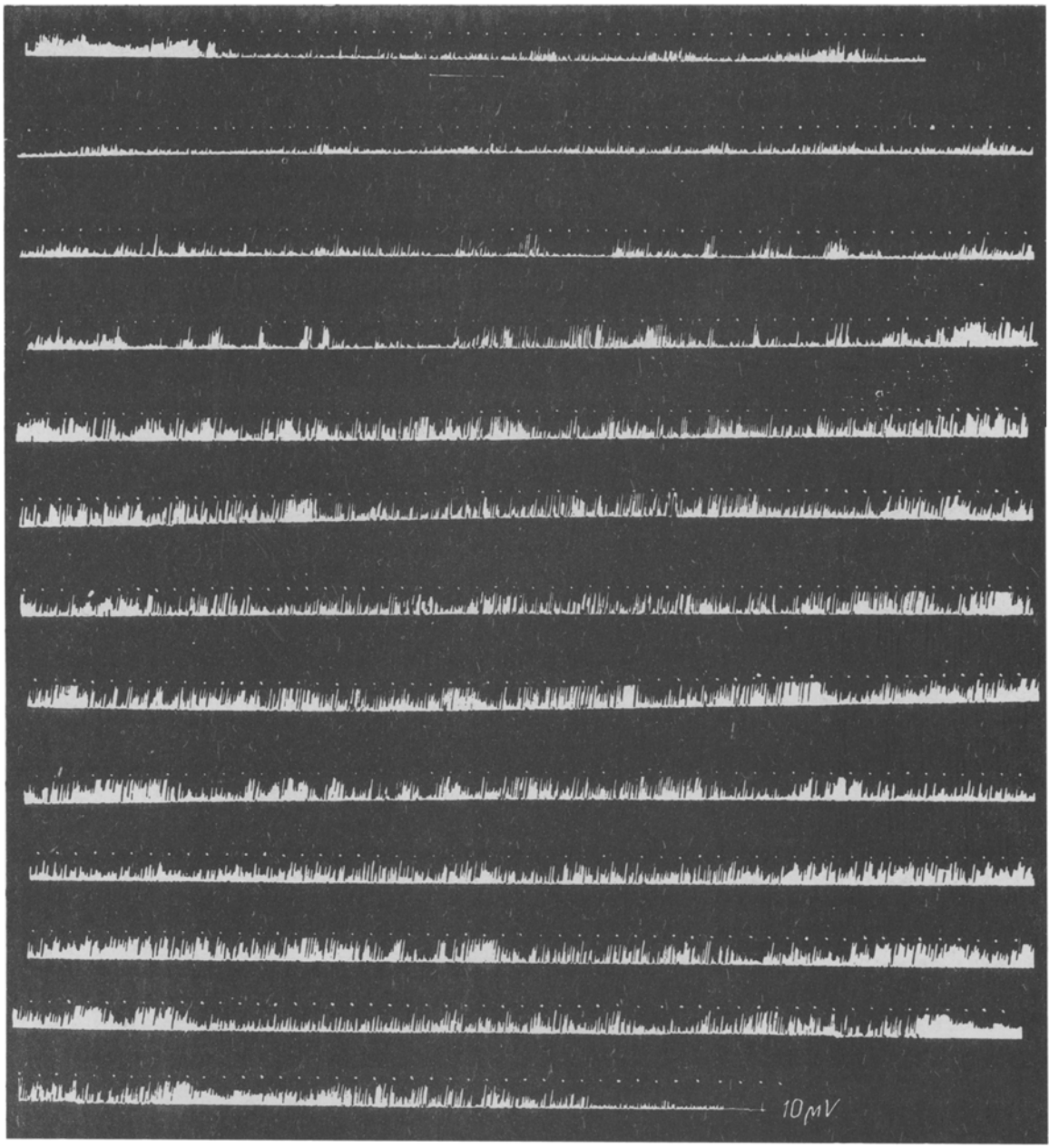

Fig. 3. Electroenterogram of duodenal motility during digestion. Food stimulus (300 g of bread) given during a "rest" period 10 minutes after the termination of the preceding "work" period. Time shown in one-minute marks above the recording. Calibration 10 mv. Experiment made February 25, 1958 on the dog Atlas.

intestinal motor function before meals and during digestion in conditions of chronic experiments. There is an electric mechanographic registration of the periods of "work" alternated by the periods of "rest", as well as of the rhythm and power of contractions. The period of duodenal "work" is equal to 30-40 minutes, on the average. The rhythm of the peristaltic waves is equal to 5 oscillations per minute, while the rhythm of the pendular motions is equal to 16-18 per minute. The period of relative rest is equal to 50-80 minutes, on the average.

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