ON THE INTERRELATIONSHIP BETWEEN THE MOTOR ACTIVITY OF THE STOMACH AND VARIOUS PORTIONS OF THE INTESTINE

V. G. Startsev

From the Institute of Experimental Pathology and Therapy (Dir.– Doctor of the Medical Sciences B. A. Lapin) of the Akad. Med. Nauk SSSR, Sukhumi
(Presented by Academician V. N. Chernigovskii)
Translated from Byulleten' Eksperimental'noi Biologii i Meditsiny, Vol. 52, No. 9, pp. 14-18, September, 1961
Original article submitted April 13, 1960

The question of the interrelationship of activity between various portions of the digestive system has been studied by many physiologists [12, 15, 16, etc.]. V. N. Boldyrev [3] first noted a correspondence between the periodic motor activity of the empty stomach and the motor activity of the small and large intestine. M. B. Tetyaeva [19], on the basis of observations of patients, concluded that in the human, with an empty stomach, a periodic motor activity is present throughout the extent of the entire intestinal tract. V. F. Mostun [10], using the multiple balloon method which permits simultaneous recording of the motor activity in the stomach, duodenum and mid portion of the jejunum, came to the conclusion that there was a temporal correspondence in the periodic effort exerted by the portions of the intestinal tract investigated. N. N. Lebedev [9] noted that the periodic motor activity of the stomach arose in synchrony with the intestinal secretion within the midportion of the jejunum and the prececal area of the ileum. Along with this, many authors [2, 4, 6, 17] do not believe there is a periodic nature to the motor activity of the large intestine.

The results of the majority of works suggest a single mechanism for the genesis and transmission of periodic motor activity serving the entire gastro-intestinal tract. In line with this, the principally important concept of a single mechanism for the periodic motor activity of the digestive tract is in need of further experimental support, using a single method for recording the motor phenomena throughout the entire extent of the gastro-intestinal tract; in the past the authors have not always taken this into consideration.

The goal of this work was to clarify any functional interrelationship between the work of the stomach and certain portions of the small and large intestine (duodenum, prececal portion of the ileum, sigmoid, and rectum) as pertains to the periodic and continuous motor activity not associated with digestion.

EXPERIMENTAL

Long term experiments were performed on 10 healthy adult dogs. In nine of the dogs fistulae were created in the stomach at the border between the pyloric and fundal portions and in the duodenum at its distal portion; in addition, in two dogs fistulae were also placed in the ileum, 10 cm proximal to the ileocecal valve. In one dog the fistulae were placed in the stomach and ileum at the same sites as in the remaining dogs. Conditions for the feeding regime and the method for recording the motor activity of the various portions of the digestive tract have been described by us in a previous work [18]. A total of 257 experiments were carried out, lasting a period of from 5 to 12 hours. The motor activity of the stomach and duodenum was recorded in 93 trials on 5 dogs; the motor activity of the stomach, and duodenum and the duodenal secretion– in 58 trials on 3 dogs; the motor activity of the stomach, duodenum and ileum– in 13 trials on 2 dogs; the motor activity of the stomach and ileum– in 52 trials on 1 dog; the motor activity of the stomach, duodenum and sigmoid– in 15 trials on one dog; the motor activity of the stomach, sigmoid and rectum– in 26 trials on 3 dogs. In the case where we recorded the actions of the sigmoid and rectum we inserted a flexible thin tube, at the end of which was a balloon, through the anus, using a rubber gloved finger; at the side of the tube, 8 cm below the first balloon, we attached a second balloon, joined to another rubber tube; when the balloons were introduced into the intestine they were located at a distance of 15-19 and 4-5 cm from the external opening of the anus.

RESULTS

The experiments confirmed a fact previously established by us; namely that outside of digestive activity there exists a strict correspondence in the functional state of the stomach and the duodenum, manifesting itself either in simultaneous, periodic activity, or in continuous activity, of these structures [18] (Fig. 1a).

The motor efforts of the lower portions of the small and large intestine, as shown by our experiments, occur independent of shifts in the functional state of the upper portion of the gastro-intestinal tract, excluding digestive activity.

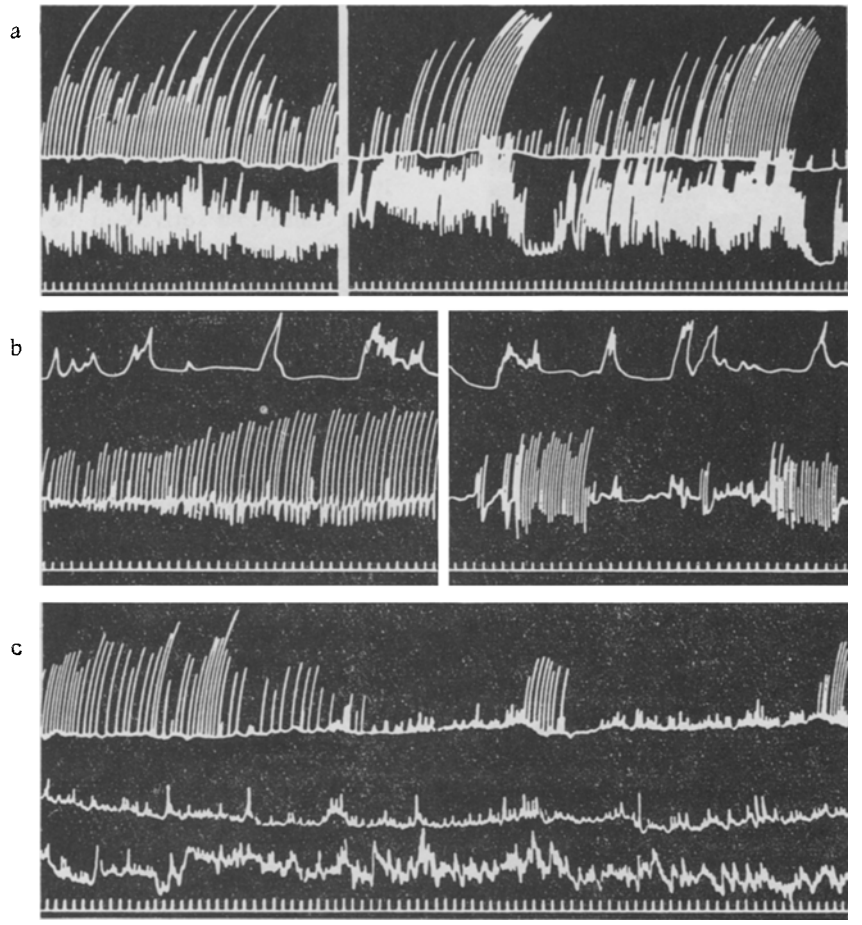

Fig. 1. The state of the motor activity in the duodenum ileum, sigmoid, and rectum in the process of transition from continuous activity of the stomach to periodic. a) Motor activity of the stomach and duodenum in the dog, V'yuna; meaning of the curves (from above downward): motor activity of the stomach; motor activity of the duodenum; time markings (3 min 20 seconds); b) motor activity of the stomach and ileum in the dog, Ryzhika; meaning of the curves (from above downward): motor activity of the ileum; motor activity of the stomach; time markings (4 min); c) motor activity of the stomach, sigmoid and rectum in the dog, Chernysha; meaning of the curves (from above downward): motor activity of the stomach; motor activity of the sigmoid; motor activity of the rectum; time markings (3 min 20 sec).

Fig. 1b shows that transition from continuous motor activity in the stomach to periodic in the same trial is not in any way reflected by the state of motor activity in the ileum. The motor activity of this portion of the dog's intestine, in the region of the ileocecal valve, independent of the presence or absence of alimentary chyme, is charac-

terized by a periodicity which does not temporally coincide with the periods of work demonstrated by the stomach. Its typical forms, encountered during a single experiment or over the course of several months of investigation, are presented in Fig. 2.

The motor activity of the ileum in the prececal area consisted of shifts from periods of relative quiet to a sharp and powerful elevation in the tonus of the intestine lasting 10-80 minutes and involving rhythmic contractions at the peak of the rise (from 5 to 20 in number). In the resting periods, lasting 5-60 minutes, rare fluctuations in the tonus of the intestine were observed as a rule. We did not observe an alternation between periodic and continuous motor activity in the ileum in a single one of the trials on the various dogs, while this was so characteristic for the stomach and the duodenum.

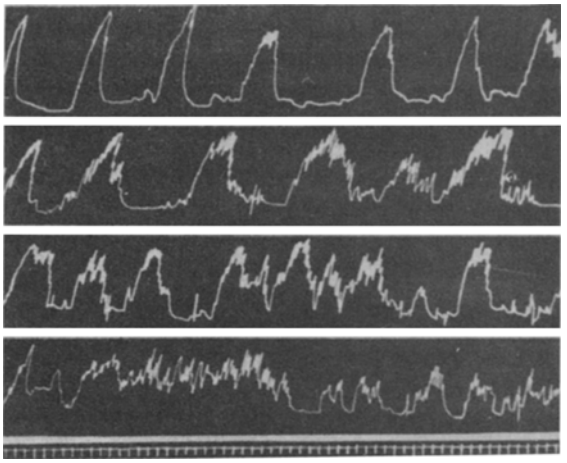

Fig. 2. The different forms of periodic motor activity of the ileum in the dog, Ryzhika, on different days of the experiment. The time markings are constant (4 min).

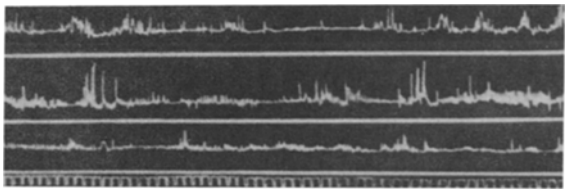

Fig. 3. Typical forms of the motor activity in the sigmoid on different days of the experiment, in the dog, Mal'chika. Below – time markings (3 minutes 20 seconds).

Thus, the motor activity of the ileum differs in a number of characteristics: first, its periodicity does not coincide temporally with the periodic activity of the stomach and duodenum; secondly, alternation between periodic and continuous activity is absent; thirdly, there are no noticeable changes during transition from continuous activity in the stomach and duodenum to periodic; fourthly, the shifts of the various forms of motor activity in the ileum occur in the presence of regular periodic motor activity of the stomach. In addition, we did not observe any kind of differences in the periodic activity of the ileum in the dogs when they were placed on a mixed diet, or in 2 dogs maintained on predominantly dairy foods. As we have shown earlier [18], the periodic motor activity of the stomach and the duodenum is markedly altered in response to changes in the nutritional regime.

The absence of an interrelationship between the motor activity of the empty stomach and the lower portion of the large intestines is shown in Fig. 1c. The transition from continuous motor activity of the stomach to periodic is not accompanied by any kind of noticeable changes in the motor activity of the sigmoid and rectum. At the same time, it can be noted that the motor activity of these neighboring portions of the large intestine is almost identical in its nature. Contractions of both portions of the intestine occur in the form of constant – sometimes weak, sometimes stronger – fluctuations in the tonus (the duration of each fluctuation is about 1 minute). In addition, periodic elevations in the tonus are observed, lasting 6-10 minutes, with rhythmic contractions at the peak of the rise. These elevations in the tonus occur irregularly; in character they are somewhat reminiscent of the periodic elevations in the tonus of the ileum. The different forms of the motor activity in the sigmoid most frequently encountered in dogs are presented in Fig. 3.

Thus, the experiments performed showed that the motor activity of the stomach and duodenum – both periodic and continuous – occurs in an interrelated fashion; the ileum, sigmoid and rectum do not take part in these alternations between periodic and continuous activity.

It may be postulated that the joint activity of the stomach and duodenum and its correspondence in time are caused, as in the case of the esophagus, pancreas and liver, by extra – and intramural nerve mechanisms common to them, apparently not related to the activity of the lower portions of the small and large intestine. The vagal mechanism for periodic, and the local ganglionic mechanism for continuous, activity of the stomach have been shown sufficiently convincingly in the works of a number of authors [1, 5, 13, 14, 19, etc.].

In the opinion of I. P. Razenkov [15], the regulating role of the central nervous system gradually weakens in a distal direction along the path of the digestive tract, which is also confirmed by other investigators. This point of view agrees with neurohistological works [7, 8] which show that with its endings the vagus forms pericellular apparatus on the Dogiel type I ganglial cells. The area of distribution of these cells basically involves only the upper portion of the digestive tract, including the duodenum. In the middle and lower portions of the small intestine and the larger part of the large intestine Dogiel type II cells are encountered, which have no relationship with the vagus. As far as the lowest portions of the large intestine are concerned, where cells of Dogiel type I are again seen, here they are served by extramural nerves from the sacral portion of the parasympathetic nervous system. The facts obtained by us can be explained by the fact that the corresponding occurrence of the periodic motor activity in the stomach and duodenum is determined by vagal nerves, while Dogiel type I ganglial cells determine the corresponding continuous activity. On the other hand, the absence of "synchronicity" in the motor activity of the upper portion of the digestive tract (stomach, duodenum) and the lower portions of the small and large intestine is apparently related to peculiarities in the extra – and intramural innervation of the lower portion of the small and large intestine.

SUMMARY

Chronic experiments were performed on 10 fistular dogs. There is evidence that the motor functions of the stomach and duodenum – both periodical and continuous – proceed in a well coordinated fashion. At the same time the motor function of the ileum, sigmoid and rectum had no periodicity characteristic of the stomach and duodenum. In the alternation of the periodic and the continuous action of the latter, no role is played by the ileum, sigmoid and rectum. It may be suggested that the coordinated activity of the stomach and duodenum in time is caused by an extra – and intramural nervous mechanism common for both of them whereas the motor function of the ileum, sigmoid and rectum is determined by other control mechanisms of the central and local nervous systems.

LITERATURE CITED

1. Bekhterov, V. M. and Mislavskii, N. A. (1889). In the book: N. A. Mislavskii, Selected Works [in Russian] (Moscow, 1952), p. 106.
2. Berlatskii, G. B., Data on the Physiology of the Large Intestine. Dissertation [in Russian] SPb, 1903.
3. Boldyrev, V. N., Periodic Activity of the Digestive Apparatus Associated with an Empty Stomach. Dissertation [in Russian] SPb, 1904.
4. Bykov, K. M. and Davydov, G. M., in the book: Neuro-Humoral Regulation of the Activity of the Digestive Apparatus in Man [in Russian] (Moscow-Leningrad, 1935), vol. 1, p. 55.
5. Denisenko, P. P., Gangliolytics [in Russian] (Leningrad, 1959).
6. Dolinskaya, A. T., Byull. Eksper. Biol. i Med., 1941, vol. 11, No. 5, p. 466.
7. Kolosov, N. G., Innervation of the Internal Organs and the Cardio-Vascular System [in Russian] (Moscow-Leningrad, 1954).
8. Lavernt'ev, B. I., in the book: Morphology of the Autonomic Nervous System [in Russian] (Moscow, 1946), p. 13.
9. Levedev, N. N., Fiziol. Zhurn. SSSR, 1959, No. 12, p. 1462.
10. Mostun, V. F., The Interrelationship of the Motor Activity of Various Portions of the Digestive Tract in Hunger [in Russian]. Avtoref. Diss. Kand. (Moscow, 1956).
11. Nekhoroshev, N. P., Russk. Fiziol. Zhurn., 1925, Vol. 8, No. 3-4, p. 59.
12. Pavlov, I. P., Complete Works [in Russian] (Moscow-Leningrad, 1951), Vol. 2, Book 2, p. 19.
13. Popov, N. F. and Sokol'skaya, N. P., Fiziol. Zhurn. SSSR, 1959, No. 3, p. 326.
14. Raeva, N. V. and Pupko, L. K., Arkh. Biol. Nauk, 1935, Vol. 38, No. 3, p. 741.
15. Razenkov, I. P., New Data on the Physiology and Pathology of Digestion [in Russian] (Moscow, 1948).
16. Rikkl', A. V., in the book: Extensive References to the Reports on the Symposium of the 9th Congress of the All-Union Association of Physiologists, Biochemists and Pharmacologists [in Russian] (Moscow-Minsk, 1959), Vol. 3, p. 56.
17. Sinel'nikov, E. I., Russk. Fiziol. Zhurn., 1931, Vol. 14, No. 2-3, p. 192.
18. Startsev, V. G., Byull. Eksper. Biol. i Med., 1958, No. 7, p. 11; Fiziol. Zhurn. SSSR, 1959, No. 9, p. 1084; Fiziol. Zhurn. SSSR, 1960, No. 4, p. 467.
19. Tetyaeva, M. B., Fiziol. Zhurn. SSSR, 1947, Vol. 33, No. 5, p. 611; Works of the Scientific Council on the Problems of the Physiology and Pathology of Digestion [in Russian] (Moscow-Leningrad, 1954), p. 207.
20. Shepoval'nikov, N. P., Physiology of Intestinal Secretion. Dissertation [in Russian] SPb, 1899.