THE RELATIONSHIP BETWEEN THE MOTOR REACTION OF THE PYLORIC PORTION OF THE STOMACH AND ITS FUNCTIONAL STATE

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(Received July 22, 1957. Presented by Active Member of the AMN SSSR V. N. Chernigovskii)

Indications have recently appeared in the literature of the great importance of the functional state of the gastrointestinal tract in the performance of its motor reactions, and that the functional state of the gastrointestinal tract is connected with the period of work or rest. P. F. Bogach [1] was the first to establish that the strength and duration of the motor reactions of the small intestine vary in relation to its functional state. An increase in the excitation of the fundal portion of the stomach at the end of a period of rest was observed by E. M. Matrosova [6].

In view of the fact that the motor activity of the pyloric region differs from that of both the fundus of the stomach and the small intestine, we decided to investigate how the excitation of the pyloric section changes at different moments of a period of rest. Such an investigation is also of interest because the motor function of the pylorus has by no means received sufficient study.

EXPERIMENTAL METHOD

Experiments were carried out on 2 dogs 16-18 hours after feeding. In the dogs, Basov-Pavlov fistulas had been made in the fundal portion of the stomach. Through the fistulas and into the stomach were passed 2 rubber balloons, attached to nippled tubes. One balloon, 5 cm long, was attached to a short tube (2-3 cm), the other – with a length 2 or 5 cm depending on the aim of the investiation – was attached to a nippled tube 10-12 cm long. The small balloon (2 cm long) on the long nippled tube was used for registration of the basal motor activity of the pylorus, and the large balloon (5 cm long) for stimulation of the pylorus and at the same time for registering its motor activity Increase in the length of the balloon, and consequently in its volume, allowed reduction of that part of the pressure inside the balloon which resulted from the elastic tension of the walls of the balloon. The large balloon (5 cm long) on the short nipple was used for recording the motor activity of the fundal portion of the stomach. In some experiments, in order to fix the balloon in the pyloric region, we inserted a third balloon into the stomach, on a nippled tube 20-25 cm long. This balloon passed through into the duodenum. The base of the pyloric balloon was attached to the nippled tube of the duodenal balloon; the balloons were passed into the stomach one after the other. A special investigation showed that inflation of the duodenal balloon with 3-4 ml of air did not essentially modify the motor activity of the pylorus. In order to record the basal motor activity, 20-30 ml of air was introduced into the balloon in the fundus and 3-4 ml of air into the balloon in the pylorus.

For stimulation, from 15 to 60 ml of air was introduced into the balloon in the pylorus. The balloons were inflated with air by means of a special apparatus which permitted not only the introduction of a definite volume of air, but also a constant watch to be kept on the pressure inside the balloons. The motor activity of the pyloric and fundal portions of the stomach were recorded on the drum of a kymograph by means of water – air or air transmission and a Marey's capsule.

EXPERIMENTAL RESULTS

In all the experiments we observed periodicity of the motor activity of the pylorus, which coincided in time with the periodicity of the motor activity of the fundal portion of the stomach. Under these circumstances typical rest periods took place in the pylorus. These findings confirm the accuracy of I. A. Edel'man's [8] point of view of the presence of periodic motor activity in the pyloric segment. American workers [12], formerly supporting the opposite view, have lately been obliged to change their minds [9]. Thus, at the present time, thanks to the work of a number of authors [4, 7, 9, 10], the presence of periodic motor activity and typical rest periods in the pyloric portion of the stomach can be considered to be firmly established.

In the middle and end part of the working period, the amplitude of the pyloric contractions underwent a number of regular changes associated with the contractions of the fundal portion of the stomach. The amplitude of the pyloric contractions was least from 15-30 seconds after completion of the fundal wave; it then gradually increased and reached its maximum at the moment of development of the next fundal wave, or slightly afterwards. The next 1 or 2 pyloric contractions remained at the maximum amplitude, after which their amplitude sharply diminished and the whole cycle of changes in the amplitude started afresh (Fig. 1). In the initial part of the period of work, when the fundal waves had not quite reached their normal size, these regularities were less clearly seen. At the end of the period of work, the variations in amplitude became particularly large.

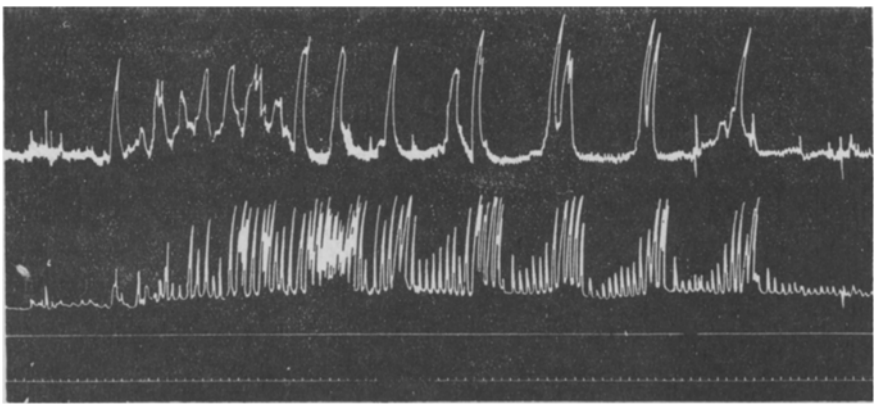

Fig. 1. Period of work in the fundal and pyloric portions of the stomach. (At the beginning of the period of work the pyloric balloon several times slipped through into the duodenum).
Significance of the curves (from above downwards): motor activity of the fundus, motor activity of the pylorus, stimulation marker, time marker (17 seconds).

On inflation of the balloon in the pyloric segment of the stomach to 20 ml during a period of work, the amplitude of the pyloric contractions was considerable increased, although the character of the variations in amplitude remained unchanged (Fig. 2, first half). On increasing the stimulating volume to 30 ml, the amplitude of the less powerful contractions continued to grow. The contractions of the pyloric segment became more even, but right at the end of the period of work the variations in the amplitude were restored.

Further distension of the stimulating balloon with air to 50-60 ml led to a diminution of the amplitude of the pyloric contractions (see Fig. 2, second half). For example, if the pyloric balloon contained 15-20 ml of air, the pressure inside the balloon during maximum contraction reached 80-90 mm of mercury, then after introduction of a further 40 ml of air it did not rise during these contractions higher than 50-60 mm of mercury. In spite of the fact that this volume was evidently excessive, when the stimulus was applied we observed no restlessness on the part of the dog. Gradual escape of air from the pyloric balloon enabled all the above-mentioned phenomena to be observed in the opposite order. The depressing influence of a strong mechanical stimulus on the motor activity of the pylorus during experiments of short duration on dogs was pointed out by McCrea and McSwiney [11].

During inflation of the pyloric balloon with 20-40 ml of air in the course of a period of rest, the appearance

of a series of 2-4 contractions of the pylorus was noted, whose amplitude rapidly fell. A similar picture during mechanical stimulation of the pyloric portion of the stomach was observed by V. F. Mostun [7]. The contractions of the pyloric portion were always accompanied by motor activity of the duodenum, and often – of the fundal portion of the stomach. As the moment of inflation of the pyloric balloon drew closer to the next working period, the reaction of the pyloric portion gradually strengthened. The contractions arising during inflation of the pyloric balloon 10-15 minutes before the start of the next period of work could be directly transformed into the contractions of the period of work. The time interval between the onset of inflation of the pyloric balloon to 20-30 ml and the onset of the period of work was not constant in the whole of the gastrointestinal tract and depended on the moment of the rest period at which inflation began. Increase in the stimulating volume to 50-60 ml strengthened the reaction up to and including cessation of the rest periods in the pylorus. The contractions occurring differed from the usual "hunger" contractions by their smaller size and also by the complete absence of the characteristic variations in amplitude. Later on the amplitude of these contractions gradually increased and at the time of appearance of the next period of work it had become maximal. We judged the onset of the period of work by the appearance of type A contractions (according to S. V. Anichkov) in the fundal portion of the stomach; in corresponding fashion the end of the period of work was determined. In spite of the quite considerable motor activity of of the pyloric portion, the fundal portion of the stomach sometimes remained at rest.

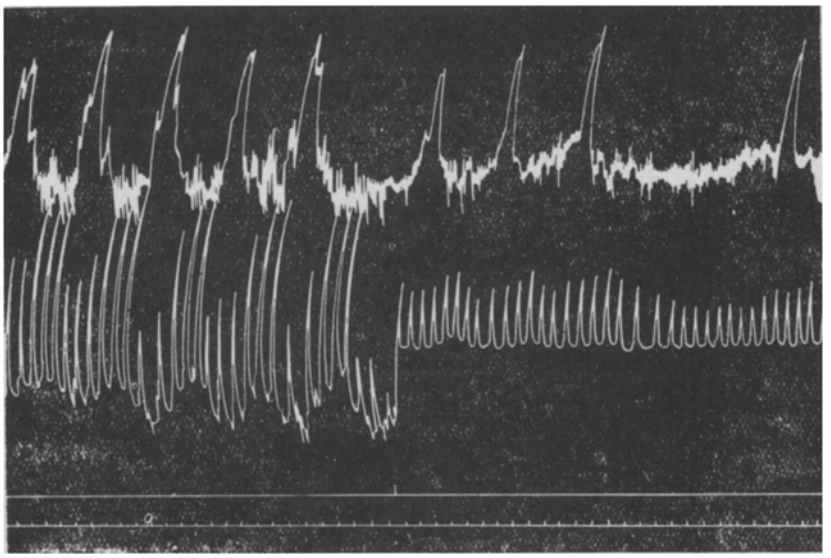

Fig. 2. The effect of strong inflation of the pylorus on its motor activity. (In the first place 15 ml of air was introduced into the pyloric balloon; at the moment indicated by a stroke on the stimulation marker an additional 35 ml of air was introduced into the pyloric balloon). Significance of the curves as in Fig. 1.

The absence of contractions of the fundus at a time when quite strong contractions were taking place in the pylorus demonstrates the relative independence of the motor function of the fundus from that of the pylorus. On the other hand, inflation of the balloon in the fundus always caused the appearance of characteristic motor activity in the pylorus at the same time as the contractions of the fundus [5]. Analysis of the curves of basal motor activity of the pyloric and fundal portions also indicates that the pyloric contractions can be changed by the influence of motor phenomena in the fundal portion of the stomach. In all this we see the manifestation of the polarity of the stomach – a characteristic property of the gastrointestinal tract which allows movement of the chyme in a caudal direction.

In some experiments the pyloric balloon, filled with 30 ml of air in the course of the period of work, remained inflated throughout the whole of the succeeding period of rest. Under these circumstances we were able

to observe how the excitation of the pylorus changes from the very beginning to the end of the rest period. A series of portions of the curve of pyloric contractions taken at different moments after the onset of the rest period in the fundus is illustrated in Fig. 3. In this experiment the pyloric balloon was inflated with 30 ml of air. As seen in Fig. 3, the least excitation in the pylorus was at the beginning of the period of rest; later the excitation of this portion of the stomach gradually increased and reached a maximum at the moment of appearance of type A contractions in the fundus. An increase in the excitation of the pyloric portion of the stomach was reflected not only in an increase of the amplitude, but also in a change in the frequency of the contractions. In one of the experiments inflation of the pyloric balloon to 40 ml in the first half of the period of rest caused contractions with a frequency of 3 per minute, but at the end of this period – a frequency of 5 per minute.

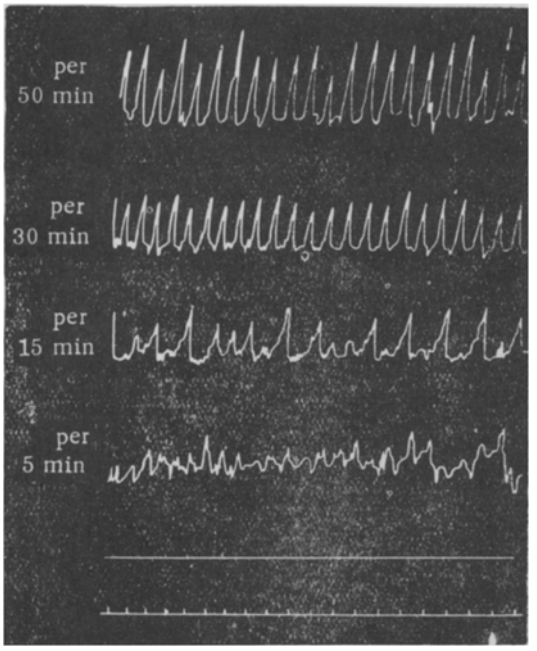

Fig. 3. Motor activity of the pylorus during inflation of the pyloric balloon with 30 ml of air. (Areas of the curve are shown which demonstrate the motor activity of the pylorus at various intervals of time after the onset of a rest period in the fundus).
Significance of the curves (from above downwards): first, second, third and fourth curves – tracings of the motor activity of the pylorus; fifth – stimulation marker; sixth – time marker (17 seconds).

Prolonged inflation of the balloon in the pylorus to 50 ml enabled the discovery of one more detail in the change of excitation of the pyloric portion of the stomach. During inflation of the balloon to the volume mentioned, the motor activity of the pylorus was more marked during the first 5-7 minutes after the onset of the period of rest than during the following 10 minutes. Later on the motor phenomena in the pyloric portion of the stomach developed exactly as described above. When we used smaller stimulating volumes, the contractions in the first third of the rest period were completely absent.

During inflation of the balloon in the pylorus, the periods of work in the fundus were lengthened, and at times they were from $1\frac{1}{2}$ to $2\frac{1}{2}$ times as long as control periods of work; at the same time the duration of the rest periods was somewhat shorter.

The experimental results show that the characteristic variations in the amplitude of the pyloric contractions during periodic motor activity depend on the motor phenomena in the fundus, since the pyloric contractions caused by inflation of the fundus [5] or by direct mechanical stimulation of the pylorus do not show these variations. Our experimental findings demonstrate that the motor reactions of the pyloric portion of the stomach during stimulation of this region during a rest period are intensified as the moment of stimulation draws nearer to the end of the period of rest. A gradual increase in the excitation of the pylorus is observed at the end of its rest period. These findings of the change in the magnitude of the motor reactions and the excitation of the pylorus at different moments of the period of rest are in full agreement with the results obtained by P. G. Bogach [1, 2, 3] from a study of the response reactions and the excitation of the small intestine.

SUMMARY

The motor function of pylorus and the effect of mechanical stimulation on the contraction of this portion of the stomach were studied in chronic experiments on dogs. Periodical motor activity in pylorus is characteristic for an empty stomach. Weak and average mechanical stimulation intensify the motor function of the pylorus, while strong ones depress it. In stimulation of the pylorus during the period of rest its motor reactions in response to stimulation are gradually intensified with the approach of the terminal phase of the period of rest.

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* In Russian.

** Original Russian pagination. See C. B. Translation.