ROLE OF LIMBIC CORTEX AND AMYGDALOID NUCLEI IN CONTROL OF MOTOR ACTIVITY OF THE GASTRO-INTESTINAL TRACT

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Stimulation of the gyrus cinguli anterior and the amgydaloid nuclei in chronic experiments on dogs during activity of the stomach and small intestine causes inhibition of their motor activity, followed by excitation of contraction of both parts of the alimentary tract and increased tone of the small intestine. Stimulation of the same brain structures while the stomach and small intestine are in a state of rest often stimulates their motor activity.

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Our previous experiments [3, 5] demonstrated participation of structures of the limbic cortex and amygdaloid nuclei in the control of the secretory activity of the gastric and salivary glands. We have also studied the role of these brain structures in the regulation of motor activity of the gastro-intestinal tract, because the available data on this problem is conflicting [1, 2, 6-10]. Most observations were made in acute experiments using general anesthetics, capable of influencing the motor activity of the gastro-intestinal tract, the physiological state of the investigated brain structures, and the effects of stimulation. N. N. Beller [1, 2] attempted to resolve some of these contradictions, but his own investigations on cats also took the form of acute experiments.

The object of the present investigation was to study the effect of stimulation of various points of the gyrus cinguli anterior and amygdaloid nuclei on motor activity of the stomach and small intestine under chronic experimental conditions.

EXPERIMENTAL METHOD

Chronic experiments were performed on 8 dogs with a Basov – Pavlov gastric fistula and with lateral fistulas of the small intestine (as described by Yakubovich). The movements of the stomach and small intestine were recorded by a balloon-graphic method. Multipolar electrodes were inserted into the gyrus cinguli anterior of 4 dogs and into the structures of the amygdaloid nuclei of another 4 dogs. The electrodes were introduced into the gyrus cinguli anterior through a burr hole in the right frontal bone. Four-point electrodes were inserted, their points being pushed into the brain tissue of the gyrus cinguli anterior to a depth of 1-2 mm. Electrodes were inserted into the amygdaloid nuclei by using the same approach and principles of operation as described previously [3] for inserting electrodes into the hypothalamus. When the hippocampal gyrus had been located, the electrodes mounted on a rectangular plate were pushed into the brain tissue until their points reached the structures of the amygdaloid nuclei. The ends of the conductors terminated in pins in a special block fixed to the frontal bone. During the experiment wires from the sources of current for electrical stimulation were connected to the pins. After the operation the location of the electrodes was confirmed roentgenologically, and after the end of the experiment it was further confirmed macroscopically in serial sections through the areas of the brain investigated.

The various points of the gyrus cinguli anterior were stimulated by sinusoidal current from a GZ-33 audio-frequency generator. The duration of stimulation was 0.5-1 min, the frequency of the current 50 Hz, and its strength from 0.1 to 3 mA. To stimulate the structures of the amygdaloid nuclei, in most experiments the strength of the current used was between 0.05 and 0.2 mA, but sometimes a current of 0.3-0.6 mA also was used. Stimulation of the brain structures was unipolar and, less frequently, bipolar.

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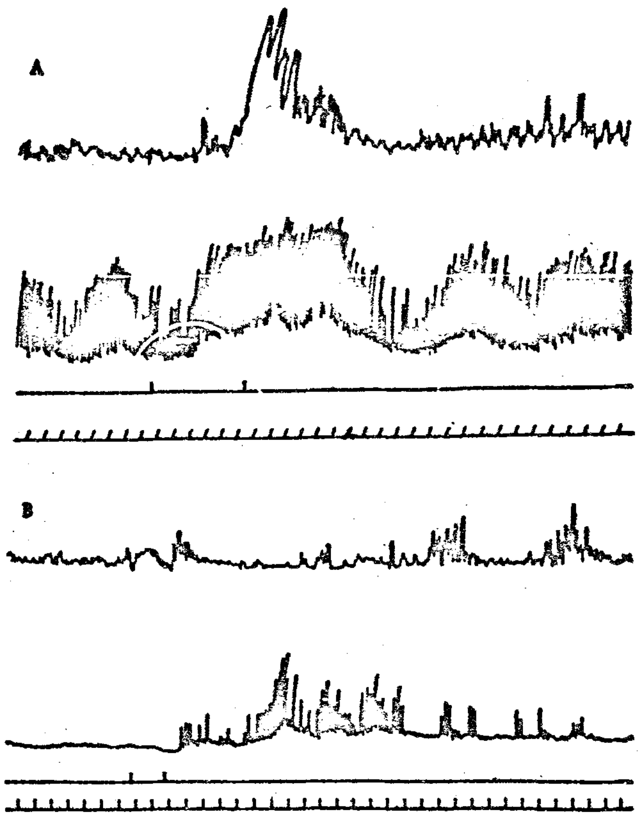

Fig. 1. Effect of stimulation of gyrus cinguli anterior with a current of 2.5 mA (A) and 2.1 mA (B) on motor activity of stomach and small intestine. From top to bottom: movements of stomach, movements of intestine, marker of stimulation, time marker (15 sec).

EXPERIMENTAL RESULTS

Stimulation of the anterior part of the gyrus cinguli often caused a complex series of somato-autonomic responses. The animal became alerted, kept very still, licked itself, urinated, and so on. In response to stronger stimulation the dogs developed a tremor, and sometimes an epileptic fit. To obtain effects on the motor activity of the gastro-intestinal tract without accompanying somatic motor responses, unipolar and bipolar stimulation with a weak current (0.1-0.8 mA) were used.

Unipolar stimulation of the gyrus cinguli anterior with an electric current of 0.5-2.5 mA against the background of active contractions of the stomach and small intestine in some experiments caused temporary inhibition of motor activity for 30-50 sec, followed by excitation. In other experiments inhibition continued throughout the period of brief stimulation (0.5-1 min), and immediately after the end of stimulation this was followed by excitation of contractions of the stomach and small intestine with an increase in the tone of the latter. However, if the duration of stimulation of the gyrus cinguli anterior was increased to 1.5 min, as a rule,the intestinal movements were increased before stimulation ended (Fig. 1A).

During unipolar stimulation of the gyrus cinguli anterior with the gastro-intestinal tract in a resting state contractions of the stomach and small intestine developed. Fairly strong contractions and an increase of tone of the small intestine developed 60-90 sec after the beginning of stimulation in most experiments, whereas the gastric movements were relatively weak (Fig. 1B). In the case of stimulation of the gyrus cinguli with the stomach in a resting state and with active movements of the jejunum, weak contractions of the stomach and inhibition of intestinal movements developed at once or 20-30 sec after the beginning of stimululation. The motor activity of both regions of the gastro-intestinal tract increased 60-80 sec after the beginning of stimulation for 1 min, the tone of the intestine increased, and intestinal peristalsis appeared. The initial reactions of the stomach and small intestine to weak stimulation of the gyrus cinguli

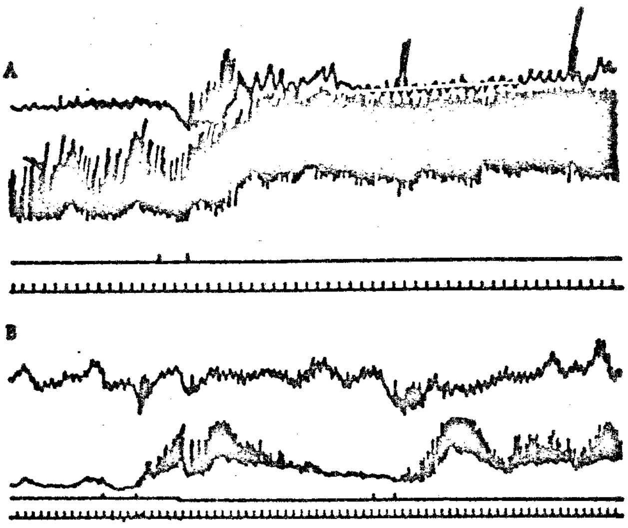

Fig. 2. Effect of stimulation of amygdaloid nuclei by a current of 0.1 mA (A) and 0.2 mA (B). Legend as in Fig. 1.

anterior thus depended on the initial physiological state of the gastro-intestinal tract at the moment of stimulation. No purely inhibitory or purely motor zones could be found in these experiments in the gyrus cinguli anterior. Often mixed effects were observed. These differences in the effects on the motor activity of the gastro-intestinal tract were largely determined by its physiological state at the time of stimulation of the gyrus cinguli.

Electrical stimulation of the amygdaloid nuclei with a current of 0.05-0.2 mA with the stomach and small intestine in a working state caused inhibition of contractions of both divisions, followed by excitation of their motor activity (Fig. 2A). The excitation developed 30-40 sec from the beginning of stimulation or immediately after the end of stimulation for 1 min. With an increase in duration of weak stimulation, excitation of intestinal movements appeared before the end of stimulation. Stronger stimulation of longer duration caused an epileptic fit. During stimulation of the amygdaloid nuclei, the excitation of the sympathetic nervous system (pilomotor reactions of the hair of the upper lip, twitching of muscles at the angles of the mouth, etc.) and the inhibitory responses of the gastro-intestine tract were more marked than during stimulation of the gyrus cinguli anterior.

Stimulation of the amygdaloid nuclei with the gastro-intestinal tract in a resting state or in the presence of weak movements of the small intestine caused slight excitation of motor activity of the stomach and small intestine 30-50 sec after the beginning of stimulation, followed by stronger excitation (Fig. 2B). Sometimes the tone of the intestine and stomach was diminished during the first 30-40 sec. In some experiments excitation following weak stimulation for 1 min did not appear until 2-3 min from the beginning of stimulation. With an increase in the strength of stimulation to 0.3 mA, signs of an epileptic fit appeared, and this sometimes became fully developed even though stimulation had been discontinued. Sometimes the fit appeared in two waves: the first wave of the fit completed its development, and after an interval of 1-2 min the second wave appeared.

The results obtained indicate similarity between the responses of the gastro-intestinal tract to stimulation of the gyrus cinguli anterior and amygdaloid nuclei. However, the inhibitory effects on gastric and intestinal movements are more marked as a result of stimulation of the amygdaloid nuclei than of the gyrus cinguli. These results show that the gyrus cinguli anterior and amygdaloid nuclei participate in regulation of the motor activity of the gastro-intestinal tract.

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