THE EFFECT OF POLARIZATION OF THE CORTEX AND SUBCORTICAL CENTERS ON THE MOTOR FUNCTION OF THE STOMACH AS SHOWN BY X-RAYS

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The effect of cortical stimulation on the motor function of the stomach has been studied in short-term experiments by many investigators [16, 17, 1, 18, 20, 13, 12]. It was found that the areas of the brain which elicited the most marked changes in the motor function of the stomach were gyrus sigmoidea of the frontal region in its lateral, anterior and posterior parts and the adjacent areas of the cerebral cortex.

The effect of the hypothalamus on the motor function of the stomach was observed in short-term experiments by Beattie [14], Bodechtel and Kaufmann [15], Gellhorn [4], and Ström and Uvnäs [19]. I. A. Chereshnev [11] reports on the effect of stimulation of these formations on the evacuation function of the stomach as shown by x-rays; he used long-term experiments and noted slowing of the passage of barium from the stomach to the duodenum when the hypothalamus was subjected to chronic stimulation.

The roentgenographic method for the study of the motor-evacuation function of the stomach has been used fairly extensively. Many investigations [3, 7, 8, 9, 2] have demonstrated roentgenologically the special features of motor function of the normal stomach in dog. Its emptying, according to these authors, occurs in 2-4½ hours, the time of the appearance of contrast medium in the duodenum being 8-20 minutes.

The aim of the present work was the roentgenographic study of the effect of stimulation of the cortex and subcortical centers on the motor function of the stomach.

EXPERIMENTAL METHOD

In our roentgenographic studies of the changes in motor function of the stomach under the influence of polarization of the frontal cortex and anterior hypothalamus we used as contrast medium a thin gruel based on 3 g barium sulfate, 3 g semolina and 20 ml water per 1 kg body weight. The gruel was cooked for 5 minutes and was slightly salted. Some dogs ate it readily, others had to be spoon-fed. Prior to the experiment the dogs were fasting for 18-20 hours. At the beginning of each experiment the dogs were given the contrast medium and x-ray pictures were taken every 20 minutes (the experiment lasted 80 minutes). The dogs, tied down on a table, lay prone during the experiment. The cassette with film was placed under the abdomen. The normal motor function of the stomach was first determined in each dog, then (after determination of normal evacuation) stimulation of the cortex or subcortical centers or combination of the two was carried out at the beginning of each experiment.

Polarization of the cortex and hypothalamus was effected by means of in-dwelling electrodes in the frontal cortex in the projection area of the sigmoid convolution using A. B. Kogan's method and in the anterior hypothalamus by the G. Ia. Khvoles method.

In a series of experiments the frontal cortex was polarized by means of a plate electrode 3 × 3 cm in area which was applied to the shaved scalp. The results were similar to those obtained by the in-dwelling electrode method.

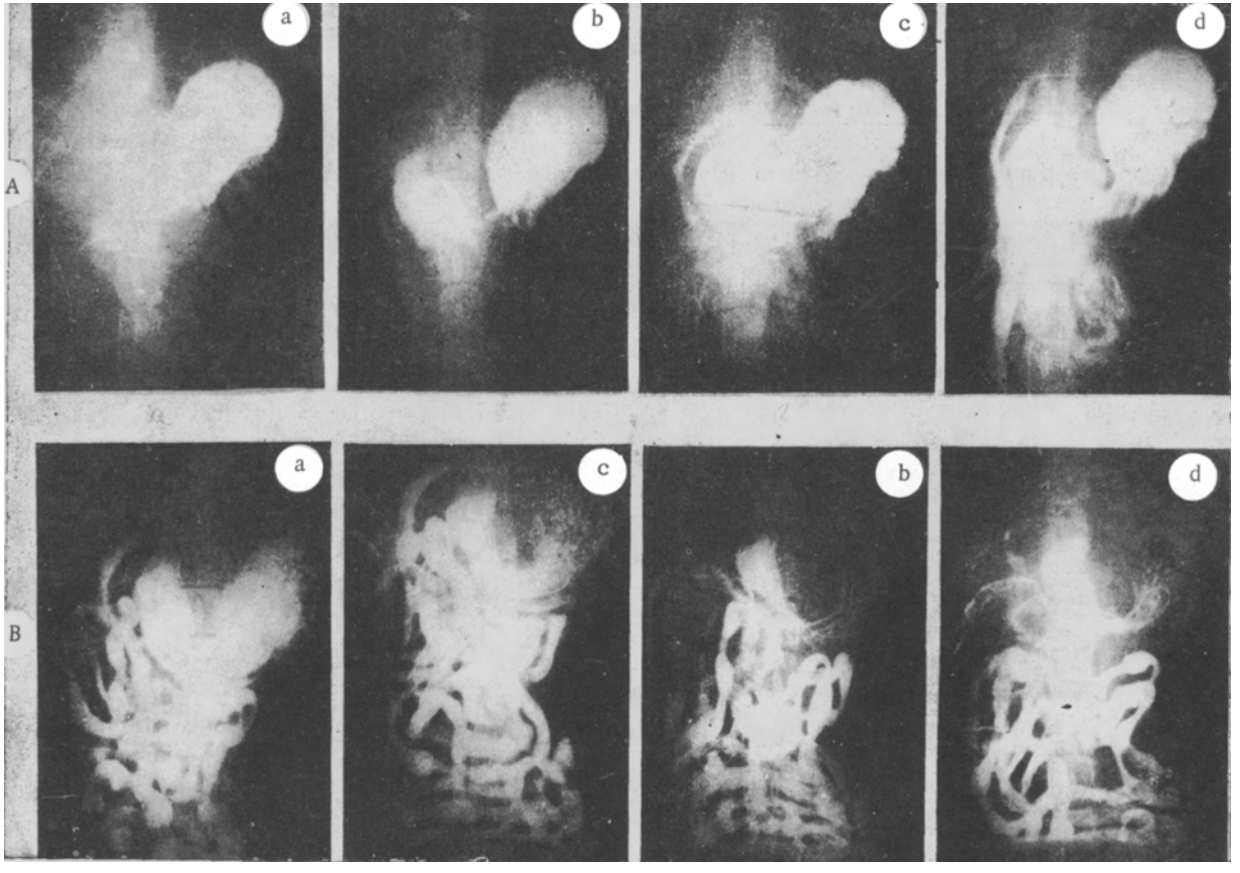

Fig. 1. Effect of galvanization of the frontal cortex with (A) cathode and (B) anode on the motor function of the stomach.

Roentgenograms of the stomach, dog Kashtanka, June 4, 1954 (upper row) and June 5, 1954 (lower row). Current strength 5 ma, duration of action 20 minutes; a) 20 minutes after stimulation; b) 40 minutes after stimulation; c) 60 minutes after stimulation; d) 80 minutes after stimulation.

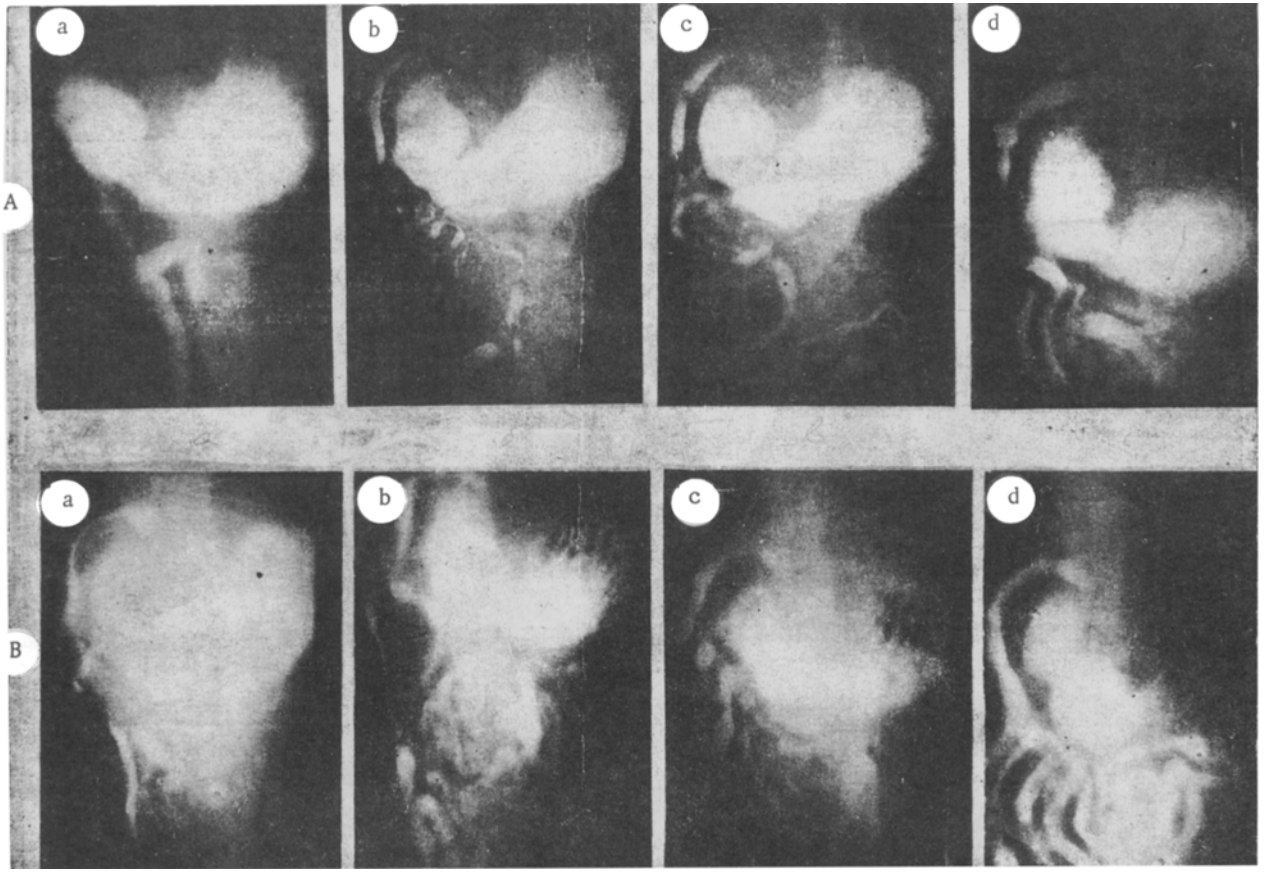

Fig. 2. Effect of galvanization of anterior hypothalamus with (A) cathode and (B) anode on the motor function of the stomach.

Roentgenograms of the stomach, dog Dzhul'bars, February 21, 1955 (upper row) and February 23, 1955 (lower row). Current strength 2 ma, duration of stimulation 10 minutes; a) 20 minutes after stimulation; b) 40 minutes after stimulation; c) 60 minutes after stimulation; d) 80 minutes after stimulation.

The indifferent electrode was placed on the dog's hind limb in the region of the outer surface of the hip.

Polarization was effected by galvanic current of 1 to 10 ma and by impulses of 0.5 - 2 ma over a period of 10-20 minutes.

The source of polarization current was a galvanizing apparatus fed by BAS-80 and GIF-constructed impulse generator.

A total of 100 experiments (400 roentgenograms) was performed on 8 dogs. In 62 experiments polarization of the cortex and subcortical centers was carried out, in the remainder the initial motor function of the stomach was determined. Emptying time as well as tone and peristalsis were studied. It is known that the shape of the stomach is in direct relation to the degree of its filling with contrast mass and to its tone. An atonic stomach has the appearance of a limp, distended bag; its volume decreases and its shape approaches the oval or spherical as the tone increases [6, 9]. During the time of an experiment (80 minutes) the contrast medium managed to pass into the intestine emptying almost the whole stomach and being retained only at the pylorus and in the duodenal bulb.

EXPERIMENTAL RESULTS

Galvanization of the frontal cortex with a cathode caused sharp depression of the motor function of the stomach. After 80 minutes the contrast medium filled the whole stomach with the exception of the upper parts of the antrum, appearing in separate portions in the small intestine. In many experiments marked demarcation of the pyloric part of the stomach was noted, caused by spasm of the prepyloric sphincter. The outline of the pylorus was not detected since it was hardly filled; its shape was elongated, indicating a sharp rise in its tone; later it was filled with contrast medium (Fig. 1, A). In a number of experiments with 10-minute galvanization the cardial-fundal part of the stomach was atonic.

Similar but even more marked inhibitory effect on the motor function of the stomach was caused by polarization of the frontal area with a cathode and impulse current at the rate of 30 to 300 impulses per second. During the 80 minutes' observation the outline of the stomach was markedly atonic in character. The pyloric tone was increased.

The slowing of passage of contrast medium from the stomach observed during cathodic polarization of the frontal cortex is thus determined by the increased tone of the pyloric sphincter and sometimes by atonia of the fundal-cardial part of the stomach.

Anodic glavanization of the cerebral cortex produced in most experiments acceleration of evacuation; less often it produced no effect. Accelerated evacuation of the stomach under the influence of anodic galvanization is illustrated by gastric roentgenograms obtained from the dog Kashtanka on June 5, 1954 (Fig. 1, B).

The current strength was 5 ma, duration of polarization 20 minutes. Evacuation function of the stomach was clearly evident on the 20th minute. Its volume decreased, and its surface showed constrictions. These are manifestations of gastric peristalsis. (The colon is filled with contrast medium which remained after cathodic stimulation of the cortex performed on June 4, 1954.).

60 minutes after administration of the contrast medium almost complete emptying of the stomach could be observed; in this experiment the spastic shape of the stomach is characteristic (Fig. 1, B).

Polarization of the frontal cortex using an anode and current impulses of frequencies equal to 30, 100 and 300 impulses per second produced in the first 40 minutes a general increase of tone in the smooth musculature of the fundal-cardial part, spasm of the prepyloric sphincter and a sharp demarcation of the body of the stomach from the pylorus (first phase). The roentgenographic appearance of the stomach was of the shrunken spherical type with sharp delineation of it from the hardly filled pylorus. Later (second phase) evacuation occurred normally and after 80 minutes' observation the stomach acquired a very elongated shape and was almost half filled with contrast medium.

Cathodic polarization of the anterior hypothalamus with impulse and galvanic current at frequencies of 30, 100 and 300 impulses per second gave inhibition of evacuation owing to gastric hypotonia and spasm of the pyloric sphincter.

The roentgenogram of the dog Dzhul'bars' stomach (Fig. 2, A) shows gastric hypotonia and pyloric sphincter spasm over a period of 80 minutes. The contrast medium fills the stomach and is present in separate portions in the small intestine.

Anodic galvanization of the anterior hypothalamus was always accompanied by timely emptying of the stomach after a preliminary (first) inhibitory phase (20-30 minutes) which was characterized by relaxation of the cardial-fundal part of the stomach.

The roentgenograms of Dzhul'bars' stomach (Fig. 2, B) after anodic stimulation of the anterior hypothalamus with current strength of 2 ma for 10 minutes show the stomach to be distended, bag-like and filled with contrast medium (first phase). After 40 minutes the contrast medium appeared in the small intestine, emptying the cardial--fundal part of the stomach; there was increase in gastric tone (second phase). A constriction appeared in the region of the prepyloric sphincter. After 80 minutes the rate of evacuation approached the initial.

The second phase of motor activity of the stomach during galvanization of the anterior hypothalamus is thus characterized by enhancement of evacuation.

Anodic polarization of the anterior hypothalamus at impulse rates of 30, 100 and 300 per second inhibited the motor evacuation of the stomach as the result of prepyloric sphincter spasm and gastric atonia which appeared 40 minutes after stimulation.

Polarization of the brain by ascending or descending galvanic or impulse current of any frequency (30, 100, 300 per second) inhibited the passage of contrast medium from the stomach to the duodenum. This inhibition occurred because of pyloric sphincter spasm and general lowering of gastric tone when polarization was effected by ascending current and only because of pyloric spasm when polarization was achieved by descending current, when gastric tone was increased and peristalsis enhanced.

The inhibitory action of descending impulse current was less marked.

The predominant effect of anelectrotonus during polarization of the cortex and subcortical centers on the motor function of the stomach was activation, that of catelectotonus was inhibition.

Our investigations confirm the data concerning the significance of the frontal cortex and the anterior hypothalamus with respect to the motor function of the stomach.

SUMMARY

Experimental data concerning the effect of stimulation of cortical and subcortical centers on stomach evacuation are presented. Cathodic stimulation of the cortex or hypothalamus depresses the evacuation function of the stomach. The anodic effect is biphasic and reveals the inductive relationship between the cortical and subcortical centers.

Simultaneous stimulation by galvanic descending current (anode on the cortex and cathode on hypothalamus), or by ascending current (cathode on the cortex and anode on hypothalamus) depresses evacuation of the stomach. Stimulation by impulse current results in more rapid evacuation.

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