LEVEL OF CLOSURE OF THE ARC OF THE ENTERO-ENTERAL INHIBITORY REFLEX

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The existence of an entero-enteral inhibitory reflex has been demonstrated by many investigators, but the level at which the arc of this reflex is closed has not been agreed to unanimously in the literature. Besides reports of experiments indicating that the spinal cord is concerned in the mechanism of inhibition of the motor activity of the small intestine, developing during stimulation of the mechanoreceptors of the intestinal wall [4, 11, 12, 17-19, 21, 22], other data have been presented, indicating that the arc of the entero-enteral inhibitory reflex may be closed at the level of the autonomic ganglia [1, 2, 5, 9, 10].

According to modern views of the pathways of the viscero-visceral reflexes, one organ may exert its influence on another via both these pathways, although the character of these influences may differ [2]. It seems probable that the entero-enteral reflexes, closed at different levels of the nervous system, may differ significantly both in the magnitude of the threshold stimulus evoking the inhibitory reflex and in the duration of inhibition of the contractions of the intestinal smooth muscle. This is confirmed by our previous findings [3], according to which stimulation of the interoceptors of a loop of bowel does not lead to permanent depression of the motor activity of its wall in anesthetized animals.

The object of the present investigation was to study the reflex pathways responsible for prolonged inhibition of the contractions of the smooth muscle of the intestine. This is important because the development of dynamic obstruction is associated with prolonged inhibition of the motor activity of the small intestine. Remembering earlier results indicating that general anesthesia affects the initial motor activity of the intestine and the character of the reflex changes in response to stimulation of the interoceptors, the experiments were conducted on unanesthetized animals.

EXPERIMENTAL

To investigate whether entero-enteral inhibitory influences could be transmitted along the intramural nerve pathways of the intestine and the mesenteric nerves, 12 experiments were carried out on an isolated loop of intestine perfused with the blood of a healthy animal. For this purpose, a loop of intestine (15-20 cm long) was resected from a healthy dog along with the mesentery and the segmental vessels. Catheters were introduced into the vessels and the loop was placed in an incubator at constant temperature. The arterial catheter was connected to a Bobrov's apparatus, filled with the aerated blood of a healthy donor dog. Perfusion was maintained under constant pressure (120 mm Hg). A rubber balloon 15-20 ml in volume, the pressure inside which was checked by means of a mercury manometer, was introduced into one end of the intestinal loop to stretch it. A small rubber balloon connected to a system for recording the motor activity was inserted into the other end of the loop. The contractions of the longitudinal muscle of the same part of the intestinal loop were recorded simultaneously by means of an Englemann's level (Fig. 1).

The changes in the motor activity of the loop of intestine resulting from stretching of another part of the loop were recorded on the drum of a kymograph both before and after division of the loop into two segments, communication between which was maintained only through the mesentery.

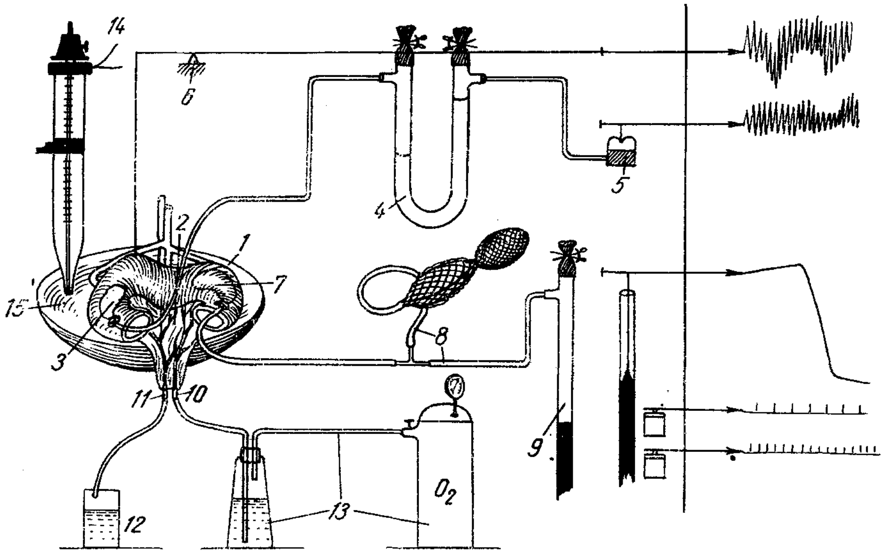

Fig. 1. Method of studying entero-enteral inhibitory influences on the isolated loop of intestine. 1) Isolated loop of intestine; 2) place of resection of loop of intestine; 3) balloon for recording contractions of circular muscle of intestine; 4) water manometer; 5) recording capsule; 6) level for recording contractions of longitudinal muscle of intestine; 7) balloon for stretching intestine; 8) system for inflating balloon; 9) mercury manometer recording pressure in ballon; 10) arterial catheter; 11) venous catheter; 12) venous reservoir; 13) system for pumping arterial blood; 14) thermometer; 15) receptacle maintained at constant temperature.

To determine the role of the autonomic ganglia, the spinal cord, and the higher levels of the central nervous system in the mechanism of the entero-enteral inhibitory reflex, experiments were conducted on unanesthetized healthy dogs in which two Thiry–Vella loops were first created. A stretching balloon was placed in one of the loops and a balloon for recording the motor activity in the other. The possibility of intramural transmission of inhibitory impulses was ruled out in these conditions.

At the beginning of each experiment the reaction of a brief (less than 1 min) and prolonged (less than 3 h stretching of the loop of intestine was recorded. The spinal cord was then transected at the level of the 6th-7th cervical vertebra. Next day, when the animal had recovered from the anesthesia, the character and duration of the entero-enteral inhibitory reflex were again investigated. Lysthenon was then given to the animal and artificial respiration applied, after which the entero-enteral reflex was again investigated, and the spinal cord was removed below the level of transection by the usual method (by means of a gouge). The character of the entero-enteral reflex was then investigated once more. Clearly, when the experiments were performed in this manner, closure of the reflex arc was possible only at the level of the autonomic ganglia.

DISCUSSION OF RESULTS

The experiments on the isolated loop showed that intensive stimulation of the mechanoreceptors of the intestinal wall by raising the pressure inside the stretching balloon to 180-200 mm Hg, caused marked inhibition of the motor activity in the neighboring portion of the intestinal loop. This inhibition lasted 15-25 sec and was followed by restoration of the motor activity despite the continuing stimulation of the mechanoreceptors. A sudden increase in pressure caused more clearly defined effects than a gradual increase (Fig. 2A).

Similar results were obtained after division of the intestinal wall, the only difference being that the inhibition was still less marked in degree and shorter in duration (Fig. 2B). In 2 of the 12 experiments after division of the intestinal loop a reaction was observed only in the longitudinal muscle of the wall (the circular muscle did not react).

In the experiments on the animals with intestinal loops isolated by the Thiry–Vella method it was found that, in the healthy unanesthetized dog, stimulation of the interoceptors arising during stretching of one loop by a balloon under a pressure of 120-140 mm Hg caused prolonged inhibition of the contractions of the smooth muscle of the second

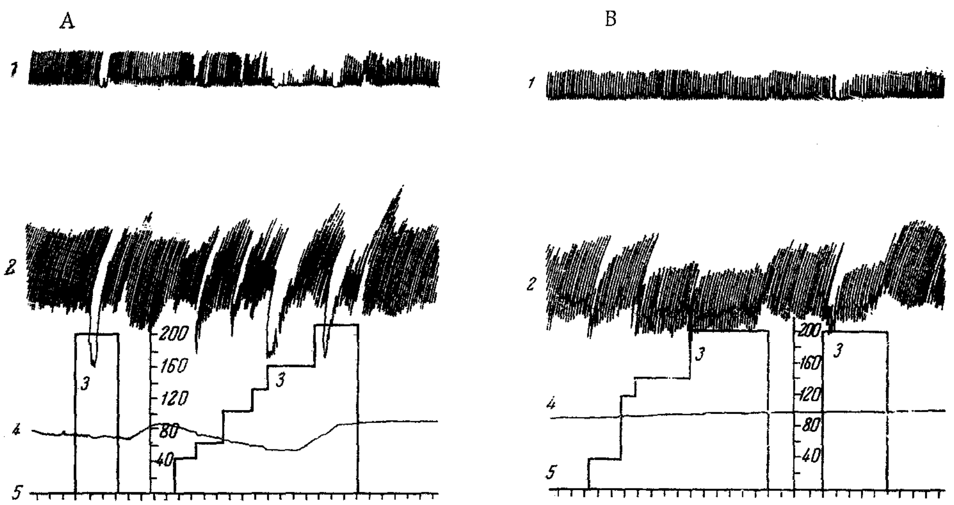

Fig. 2. Changes in motor activity of a portion of the loop of intestine during stimulation of the mechanoreceptors of another portion. A) Reaction before division of intestinal loop; B) reaction after division of intestinal loop; 1) contraction of circular muscle of intestinal wall; 2) contraction of longitudinal muscle of intestinal wall; 3) pressure inside stretching balloon; 4) perfusion pressure; 5) time marker (30 sec).

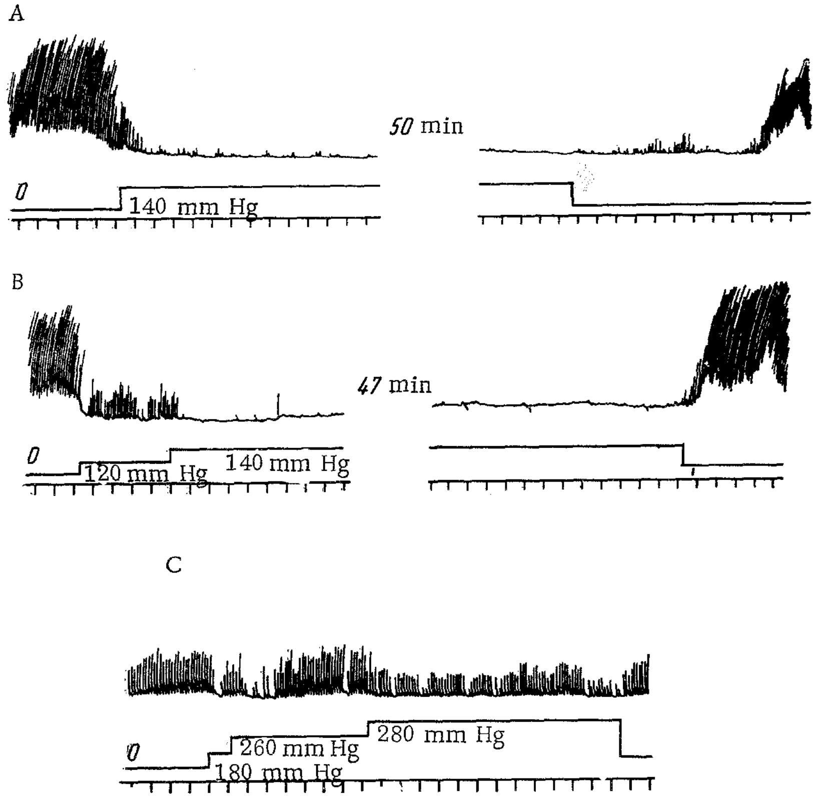

Fig. 3. Entero-enteral inhibitory reflex in a healthy dog (A) and in a dog after division (B) and removal (C) of the spinal cord. Significance of the curves (from top to bottom): recording of contractions of circular muscle of Thiry–Vella intestinal loop; marker of stimulation; time marker (30 sec).

intestinal loop. This inhibition lasted throughout the time of stimulation of the interoceptors and for 5-15 min thereafter. After the cessation of stimulation, the amplitude of the contractions of the intestinal muscle regained its initial level only gradually (Fig. 3A).

In the animals undergoing transection of the spinal cord the threshold of the entero-enteral inhibitory reflex was the same or slightly lower, and the inhibition also lasted throughout the period of stimulation of the mecahno-receptors. But restoration of the contractions of the intestinal muscle took place soon after the distension of the loop of intestine was discontinued (Fig. 3B). The same reaction was also observed in the dogs after administration of lysthenon.

The character of the entero-enteral inhibitory reflex in the dogs whose spinal cord had been removed was exactly the same as that observed in the isolated intestinal loop (Fig. 3C).

These experiments showed that inhibition of the contractions of the intestinal smooth muscle produced by stimulation of the interoceptors of the small intestine was the result of both a true reflex, closed in the spinal cord, and peripheral reflexes closed outside the central nervous system. The character of the peripheral reflexes cannot be judged from these results. They may be either axon reflexes, as described by Langley [20], L. A. Orbeli [13], A. V. Tonkikh [16], and others, or intra-autonomic reflexes from Dogiel type II cells to Dogiel type I cells [7, 8, 11, 14]. All that can be said for certain is that neither these reflexes nor the reflexes closed at the level of the autonomic ganglia are responsible for the protracted depression of the motor activity. The character of the observed reactions indicates that the degree of inhibition depends, not so much on the magnitude of the stimulus, as on the increase in pressure in unit time ($\Delta p/\Delta t$).

The experiments showed that the prolonged inhibition of the motor activity developing during stimulation of up to a certain threshold intensity was caused by a reflex whose arc was closed at the level of the spinal cord. This follows from the fact that prolonged inhibition persisted after division, and disappeared after removal, of the spinal cord.

The higher levels of the central nervous system also take part in the mechanism of prolonged inhibition. Its apparent role is to "form an impression" of the discontinued stimulus and in this way to maintain the inhibition of the motor activity after stimulation of the interoceptors of the intestine has ceased. This role is also manifested as the appearance of weak contractions before the motor activity proper is restored. The role of the higher levels of the central nervous system is evidently exerted, not by means of a special reflex whose arc is closed in them, but by means of mechanisms analyzing the incoming information and exerting a regulatory influence on the spinal cord.

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