VARIATIONS IN MOTILITY OF THE SMALL INTESTINE AND THE EFFECT OF IMPULSES IN INTESTINAL NERVES DURING STIMULATION OF THE MECHANOCEPTORS OF A LOOP OF SMALL INTESTINE

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The reflex nature of inhibition of motility of the small intestine caused by stimulation of the mechanoceptors of various sections of the digestive tract is universally admitted. By special studies the mechanisms which bring about this inhibition have been determined.

It has been shown [1, 4, 8, 9, 12, 13] that the vagus and sympathetic nerves play an important part in mediating this inhibitory reflex. One of the factors involved is the liberation of adrenalin by the adrenals in response to stimulation of the mechanoceptors of the gastrointestinal tract [2, 12]. The results obtained [3, 7, 11] indicate that peripheral reflexes play an important part in these inhibitory reflexes.

The nature of the impulses in the splanchnic nerves concerned in reflex inhibition has not been adequately studied. O. N. Zamyatina [5, 6] described changes in the afferent and efferent impulses in the splanchnic nerves on the stimulation of the mechanoceptors of the gastrointestinal tract; however we have found no comparable results on changes of motility in the small intestine in relation to variations in the potentials in the efferent nerve supplying it. The problem is of interest in connection with central regulation of motility of the gut, and forms the subject of the present investigation.

EXPERIMENTAL METHOD

We carried out 60 acute experiments on cats and dogs. A median incision was made into the abdominal cavity under morphine-thiopentane anesthesia; we removed a 10-12 cm length of ileum above the cecum. On both sides the mesentery was divided completely. In the lumen of the separated length of intestine we introduced a rubber balloon connected to a catheter leading to a mercury manometer. The indications of the manometer when the balloon was inflated were recorded on a kymograph. To record the contractions of the longitudinal and circular muscles of the intestine we used a higher portion of ileum. Contractions of the circular muscles were recorded by a rubber balloon attached to a catheter and introduced rostrally into the incision after a purse-string suture had been made in the wall of the serous-muscular lining. The outer end of the catheter was connected with a water manometer, whose second limb was connected to a Mostun capsule. To record the contractions of the longitudinal musculature of the same segment of intestine, both ends of the loop were fixed to a П-shaped glass tube, and the middle of the segment was connected to an Engelman lever. Contractions of both circular and longitudinal muscles were recorded on a kymograph. In some of the experiments we also recorded the respiration by connecting the trachea with a Marey's capsule.

In 31 experiments, besides the manipulations we have described, we also dissected out the splanchnic nerve at the root of the mesentery and by means of platinum electrodes separated by 3 mm we recorded the efferent potentials in it. We used a capacitor-coupled amplifier with a bandwidth of 1-1500 cycles and a noise level of 2-3 μv. Recording was by a string oscillograph type MPO-2 having a spot velocity of 50 mm/sec.

EXPERIMENTAL RESULTS

In all the experiments stimulation of the mechanoceptors of the loop of ileum was caused by dilating a balloon

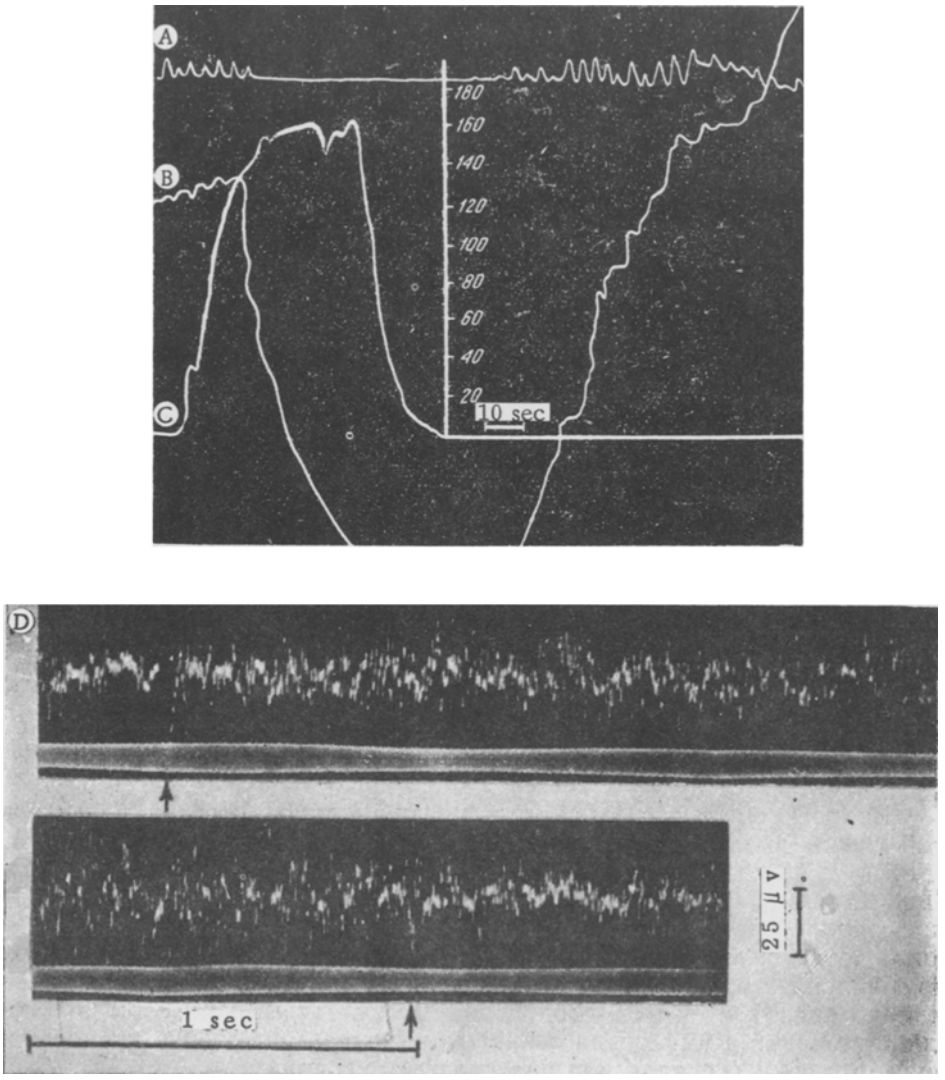
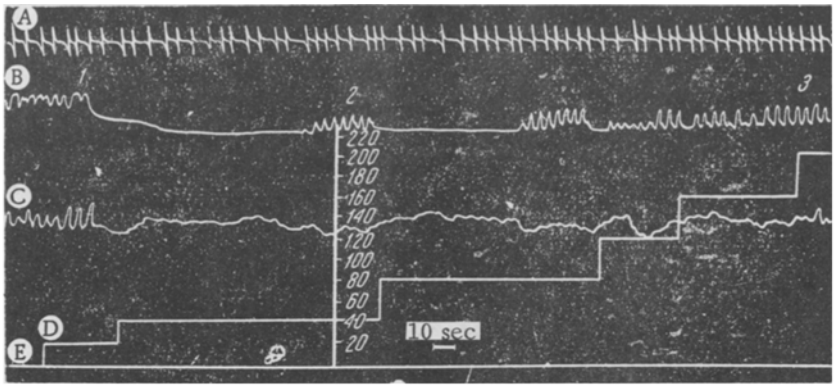


Fig. 1. Change of motility of the small intestine and the efferent impulses in the splanchnic nerve in response to a brief stimulation of the mechanoceptors of a loop of ileum. A) Contraction of the circular musculature of the jejunum; B) contraction of the longitudinal musculature of the jejunum; C) pressure in a balloon introduced into a loop of ileum; D) efferent impulses in the mesenteric nerve. The arrows indicate the onset and cessation of stimulation of the mechanoceptors of the ileum.

to 40-180 mm mercury; it causes a marked inhibition of the whole of the small intestine. Contraction of the circular muscles ceased completely; however contraction of the longitudinal muscles was as a rule maintained, although the tone was greatly reduced. When the air was allowed to escape rapidly from the balloon there was a rapid recovery of the contractions of the circular muscles and of the tone of the longitudinal muscles. As a rule both these quantities then recovered to beyond their original level.

The nature of the efferent impulses in the splanchnic nerve at the start of the stretch of the loop of ileum changes greatly: the amplitude of the potentials rose to 30-40 μv from an original level of 15-20 μv, and superimposed on the "slow" pulses there were relatively rare high-amplitude pulses of the order of 50 μv occurring at a frequency of 9-31/sec, and having a very steep front. When stretching of the balloon had ceased the impulses returned to their original condition. In many cases these effects were preceded by a short period in which the impulses were suppressed (Fig. 1). If the intestinal loop was held in a distended condition for 10-30 min, after a 2 minute period of suppression



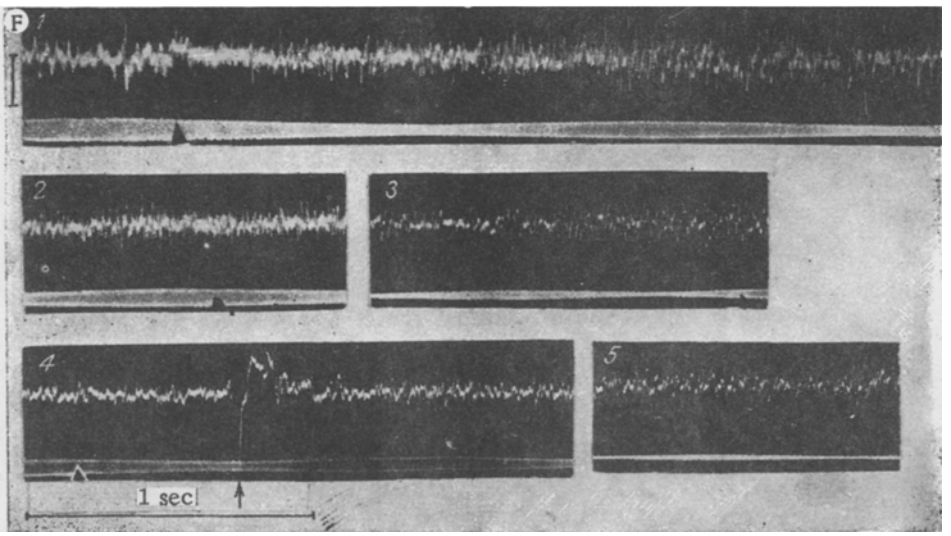


Fig. 2. Change of motility of the small intestine and of the efferent impulses in the splanchnic nerve during prolonged and increasing stimulation of the mechanoceptors of the loop of ileum. A) Respiration; B) contraction of the circular musculature of the jejunum; C) contraction of the longitudinal musculature of the jejunum; D) pressure in the balloon introduced into a loop of ileum; E) zero line for pressure; F) efferent impulses in the splanchnic nerve during prolonged stimulation; 1) onset of stimulation of the mechanoceptors of the ileum; 2, 3) record made during maintained stimulation; 4) stimulus removed (as indicated by arrow); 5) after removal of stimulus.

of motility, despite the maintained stimulus to the mechanoceptors the contractions of the circular musculature recommenced and the tone of the longitudinal muscle returned to its original level. As a rule further increase of pressure in the balloon gave a still more transitory effect, and then almost ceased to influence the muscular contractions of the intestine; despite the fact that the pressure was maintained in the isolated loop at approximately 200 mm mercury the intestinal motility remained unchanged. Releasing the air after prolonged distension of the loop was quite frequently associated with inhibition of motility. Then the record of the potentials of the efferent nerve showed that a response similar to the one we have described occurred immediately after the release of pressure. However, subsequently, despite the maintained stimulation of the mechanoceptors the "rapid" impulses ceased and the amplitude of the potentials fell noticeably, and before the distension in the loops was removed it became set at a value below the original level.

For the first 5-10 min after the air had been released from the balloon the impulse pattern resembled the original picture (Fig. 2). In attempting to eliminate the reflex inhibition of motility brought about by stimulation of the mechanoceptors of an intestinal loop we applied a ganglion block by the injection of from 3 μg to 1 mg dicoline per kg. Under conditions of an acute experiment the injection of the preparation caused a marked stimulation of

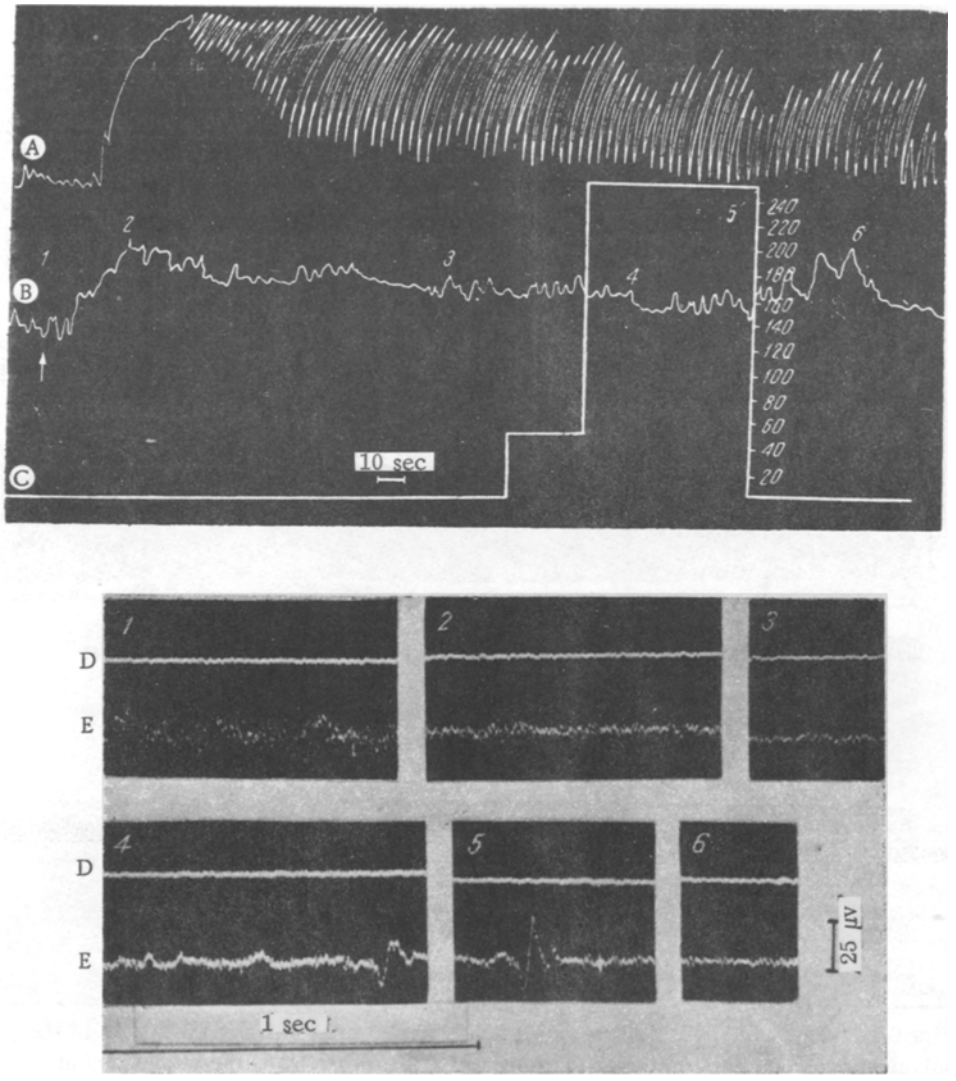


Fig. 3. Change of motility of the small intestine and of the efferent impulses in the splanchnic nerves during the injection of dicoline (1 mg/kg). Moment of injection indicated by the arrow. A) Contraction of the circular musculature of the jejunum; B) contraction of the longitudinal musculature of the jejunum; C) pressure in the balloon introduced into a segment of ileum; D) noise with input to the second channel short-circuited; E) efferent impulses in the splanchnic nerves; 1) original condition before injection of dicoline; 2,3) condition after the injection of dicoline; 4) stimulation of the mechanoceptors of the ileum; 5) stimulus removed; 6) after removal of stimulus.

motility which was best shown when the amount injected was 50-100 μg/kg. Further increase of the dose had practically no effect on motility. Under these conditions stimulation of the mechanoceptors by any intensity (260-280 mm mercury in the balloon) caused no appreciable inhibition.

In these experiments the change of efferent impulses depended on the amount of preparation injected. Small amounts (3-5 μg/kg) caused a transient reduction in the amplitude of the potentials to 20-50 μv below their original value. A superimposed stimulation of the mechanoceptors of the intestinal loop caused an increased efferent impulsation, but it was much less well shown than it had been before the injection; after 10-15 min the potential variations returned to the original value. After the injection of 10 μg/kg of the drug a similar response was obtained, and the only difference was that after stimulation had ceased the impulses remained depressed. The injection of large amounts of dicoline (100 μg - 1 mg/kg) caused a permanent reduction in the potentials due to the efferent impulses (they fell to 7-10 μv), and under these conditions distension of the intestinal loop caused no change in the impulses (Fig. 3).

A comparison of the record of the movements from the small intestine recorded with the change of efferent impulsation in the splanchnic nerve showed that each burst of impulses produced a suppression of movement, and correspondingly any decrease in the number of impulses was associated with increased motility.

The fact that increased impulsation and depression of motility occur during distension of the loop leads us to suppose that the two processes are causally related. Evidently stimulation of the mechanoceptors of the loop causes a burst of efferent impulses in the splanchnic nerve which is ultimately responsible for inhibition of motility of the small intestine. That there is a relation between the nature of the impulsation and the condition of motility is confirmed also by the fact that the reduction of impulsation to a level below that which existed originally and which occurred on prolonged stimulation of the mechanoceptors was accompanied by a recovery of motility. Further evidence is that the sharp reduction in the number of impulses during ganglion block was associated with a marked increase of intestinal movements.

The causal relationship between the changes of potentials representing efferent impulses and the degree of motility is also shown by the fact that during ganglion block stimulation of the mechanoceptors produced no changes of impulses and did not alter motility. This last fact is also proof of the reflex nature of the inhibition of small-intestinal movements caused by stimulation of the mechanoceptors of the digestive tract. Reduction of impulses in the efferent nerves associated with prolonged distension may be explained as being the result of adaptation of the nervous centers to the prolonged receptor stimulation [10].

SUMMARY

Acute experiments were carried out on cats and dogs. Movements of the small intestine were compared with changes in the potentials recorded from the splanchnic nerve. It was found that an increase of impulses was accompanied by a depression of motor function, and that increased motility was associated with a depression of the impulses. It was also established that stimulation of the mechanoceptors of the small intestine which caused an increased rate of firing of efferent impulses led to the inhibition of motor function. Ganglion block caused by dicoline administration sharply decreased the level of impulsation, caused a marked increase of motor function, and eliminated the response to stimulation of mechanoceptors of the segment of intestine.

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