ROLE OF THE RETICULAR FORMATION IN REGULATION OF THE INTEROCEPTIVE REFLEX REACTIONS OF THE STOMACH AND SMALL INTESTINE

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There are many reports in the literature that the reticular formation not only is responsible for changes in cortical tone, but is also actively concerned in the regulation of the autonomic functions of the living organism [1,2,3,4,5,10]. Meanwhile the interoceptive impulses and, in particular, impulses arising in the carotid sinus and aortic zones, the stomach, and the intestine intensify the activity of the reticular formation [3,9]. However, the problem of the extent to which the reticular formation takes part in the regulation of the reflex interaction between the stomach and the small intestine has not yet been studied.

The object of the present investigation was to study the role of the mesencephalic and bulbar portions of the reticular formation in the regulation of the interceptive reflex reactions of the stomach and the small intestine, and also to study how this regulation is associated with the influence of the reticular formation on the functional state of the cerebral cortex.

EXPERIMENTAL METHOD

Experiments were carried out on 18 dogs with electrodes permanently implanted in the region of the reticular formation of the mesencephalon and the medulla and in the cranial bones at the site of projection of the frontal, the parietal, and the occipital regions of the cerebral cortex. The electrodes were implanted and their position verified by the method of A. M. Marits [8]. In all the animals a loop of the proximal portion of the small intestine was isolated by Thiry's method and a fistula was prepared by Masow's method in the fundal part of the stomach.

The reticular formation was stimulated in bipolar conditions by series of rectangular pulses from an electronic stimulator within a frequency range of 100 cps, at a voltage of between 0.2 and 2.0 V, for 1.5-3.0 min. The voltage of the current was chosen individually for each dog so as to produce a well marked orienting reflex. The electrical potentials of the reticular formation and cortex were recorded by bipolar electrodes on a type ChEEG-1 four-channel ink-writing electroencephalograph, within a frequency range of 3 and 100 cps, and with an interelectrode resistance of 20-50 kΩ. The motor activity of the stomach and small intestine was recorded by a balloon method, using hydropneumatic transmission. The baroceptors of the stomach or small intestine were stimulated by inflation of thin-walled rubber balloons introduced through the orifices of the fistulas into the cavity of the stomach and small intestine. The chemoceptors were stimulated with 0.5% hydrochloric acid solution.

EXPERIMENTAL RESULTS

Besides causing activation of the electrical potentials of the reticular formation and cerebral cortex, stimulation of the baroceptors of the stomach (25-35 mm Hg) also caused a reflex stimulation of the motor function of the proximal portion of the small intestine. Stimulation of the reticular formation of the medulla through the electrodes implanted therein abolished the reflex influence of stimulation of the baroceptors of the stomach on the motor activity of the intestine, leading to inhibition of its contractions (Fig. 1). Stimulation of the reticular formation of the mesencephalon by a current of the same voltage inhibited the gastro-intestinal reflex if the intestinal movements were excessively strong; if the intensity of the movements was average, it increased it. These effects of stimulation of the reticular formation on the gastro-intestinal baroceptor reflex lasted for a few minutes after stimulation stopped, indicating that a humoral link was possibly involved in them.

Stimulation of the baroceptors of the proximal portion of the small intestine (30-80 mm Hg) led to total inhibition of the spontaneous gastric movements and at the same time intensified the bioelectrical activity of the

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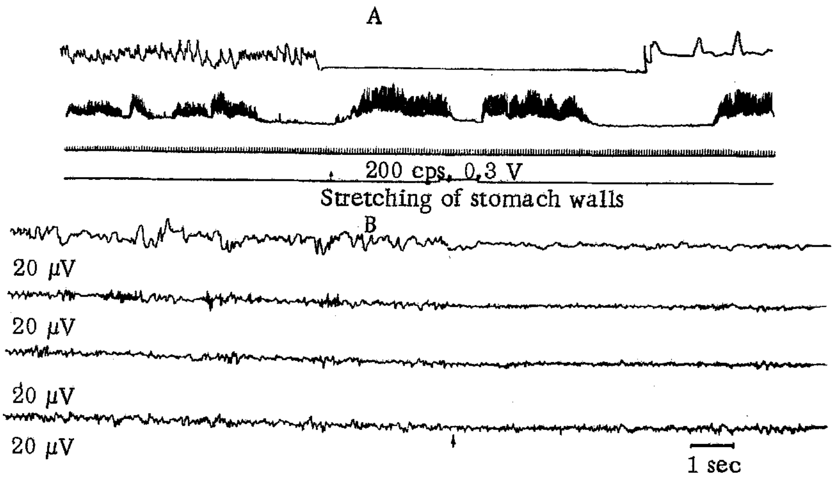

Fig. 1. Effect of stimulation of the region of the reticular formation of the medulla on the gastro-intestinal reflex (A) and the EEG of the brain (B). From top to bottom: A) motor activity of the stomach, intestinal motor activity, time marker (3 sec), marker of stimulation; B) EEG of the mesencephalic reticular formation and of the frontal, parietal, and occipital zones of the cortex. The arrows point to the moment of stimulation of the baroceptors of the stomach.

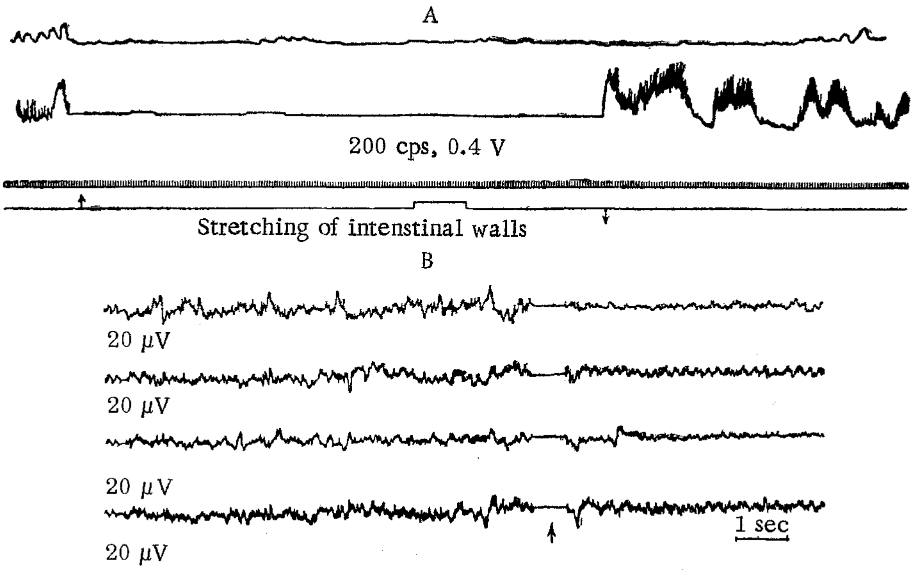

Fig. 2. Effect of stimulation of the reticular formation of the medulla on the gastro-intestinal reflex. From top to bottom: A) motor activity of stomach, intestinal motor activity, time marker (3 sec), marker of stimulation; B) EEG of frontal and parietal zones of cortex, of reticular formation of the mesencephalon, and of occipital cortex. The arrows point to the moment of stimulation of the baroceptors of the intestine.

reticular formation and of the cerebral cortex. The reflex inhibition of the gastric contractions during stretching of the walls of the small intestine appeared the sooner, and was the more marked, the stronger the inflation of the balloon, and it was independent of the preceding functional state of the stomach. With the cessation of mechanical stimulation of the intestine, the gastric contractions were quickly and completely restored; they began to recover within 2 min after stimulation of the intestine stopped. If the stretching of the intestine was strong and prolonged, the gastric movements ceased altogether and the bioelectrical activity of the reticular formation and cortex increased to a high degree.

Fig. 3. Intensification of the gastro-intestinal reflex evoked after stimulation of the mesencephalic reticular formation. From top to bottom: motor activity of stomach, intestinal motor activity, time marker (3 sec), marker of stimulation. The arrows denote the moment of stimulation of the baroceptors of the stomach.

Electrical stimulation of the reticular formation in both the mesencephalon and the medulla, carried out during stretching of the intestinal walls, in most experiments had no effect on the gastro-intestinal reflex (Fig. 2), but sometimes an effect was present. In these cases stimulation of the mesencephalic reticular formation caused a small increase in the tone of the stomach and stimulated its peristalsis, whereas stimulation of the reticular formation of the medulla deepened the inhibition of the gastric movements.

The reticular formation of the brain stem is thus a regulator of the reflex interaction between the stomach and small intestine. Its regulatory effect on this interaction is more marked in relation to the reflex from the baroceptors of the stomach on the intestinal motor activity than to that from the baroceptors of the small intestine on the gastric movements. This effect is mainly inhibitory.

In a series of experiments, the gastro-intestinal and intestino-gastric baroceptor reflexes were evoked after stimulation of the reticular formation had ceased. If the balloon in the stomach was inflated after stimulation of the mesencephalic reticular formation, the reflex increase in the intestinal tone was far greater than usual (Fig. 3). If, on the other hand, the balloon in the stomach was inflated immediately after stimulation of the reticular formation of the medulla, and not of the mesencephalon, the increase in tone was accompanied by an increase in the frequency and amplitude of the intestinal contractions.

Against the background of the intravenous injection of chlorpromazine (1-2 mg/kg), the gastro-intestinal and intestino-gastric baroceptor reflexes remained but they were modified: in some experiments their amplitude was reduced and their latent period lengthened to 3-5 min, while in others they became periodic in character and sometimes their amplitude increased very considerably. These variants were evidently associated with individual differences between the experimental dogs, because this dose of chlorpromazine always had the same effect on each cf them.

If chloropromazine was injected intravenously, not before distension of the stomach, but during distension, the reflex reaction from the stomach on the intestine, having begun, thereupon decreased sharply. The decrease in the reflex took place at the same time as the depression of the biopotentials of the reticular formation and the cortex by chlorpromazine. At this time, however, the effect of the reticular formation on the reflex interaction of the stomach and intestine had not yet disappeared; stimulation of its bulbar portion nevertheless inhibited the gastro-intestinal reflex; its inhibition was short in duration but complete.

During stimulation of the reticular formation, besides changes in the reflex interaction between the stomach and small intestine, other effects were observed: a quickening of respiration, changes in the pulse rate, and so on. During stimulation of the reticular formation of the mesencephalon these autonomic effects were less pronounced.

The experiments in which the reflex interaction between the stomach and intestine and the influence of the reticular formation of the mesencephalon and medulla on this interaction were investigated during stimulation of the chemoceptors, rather than the baroceptors, of these organs gave essentially the same results. Stimulation of the chemoceptors of the stomach by hydrochloric acid solution caused an increase in the tone and in the intensity of the motor activity of the intestinal loop, and the same stimulation of the chemoceptors of the loop of small intestine inhibited the movements of the stomach and caused a sharp decrease in its tone. Both reflexes were accompanied by an increase in the bioelectrical activity of the bulbar and the mesencephalic portions of the reticular formation and, at the same time, of the cerebral cortex. Stimulation of the bulbar portion of the reticular formation inhibited the gastro-intestinal intensifying reflex and deepened the inhibition of the stomach caused by stimulation of the intestine. Stimulation of the mesencephalic portion of the reticular formation acted in a similar way, but to a lesser degree and not in all the experiments. Intravenous injection of chlorpromazine did not abolish the reflex interaction between the stomach and the small intestine, but changed the character of the reflexes, their latent period, and their amplitude.

It follows from the foregoing facts that the reticular formation of the brain stem, although not participating directly in the reflex interaction between the stomach and the small intestine, is nevertheless an important regulator of this interaction. This corresponds to the concept of the adaptive function of the reticular formation [6,7]. Besides the influence of the reticular formation on the gastro-intestinal and intestino-gastric baroceptor and chemoceptor reflexes, these reflexes have a reverse influence on the reticular formation, expressed by evoked changes in its bio-electrical activity and, through it, in the bioelectrical activity of the cerebral cortex. Of the two portions of the reticular formation, bulbar and mesencephalic, it is the bulbar which has the strongest influence on the reflex interaction between the stomach and intestine, whereas the mesencephalic portion has its strongest influence on the cerebral cortex. However, the influence of these two portions in both directions provides evidence of their functional unity.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of the first issue of this year.