CHARACTERISTICS OF THE MECHANISM OF ASCENDING ACTIVATION OF THE CEREBRAL CORTEX IN MECHANICAL IRRITATION OF THE STOMACH

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Abundant evidence in the literature indicates that mechanical irritation of the stomach causes activation of the cerebral cortex [2, 5-7, 9, 11, 13].

It has been demonstrated [14-17] that ascending activation of the cerebral cortex is to a considerable extent determined by the corresponding apparatus of the reticular formation of the brain stem. Further experiments established that ascending activation of the cerebral cortex during reactions of a different biological quality is always selective and specific and can arise in various apparatus of the subcortex [3].

In this investigation we determined the biological significance of certain neurophysiological characteristics of specific ascending activation of the cortex with mechanical irritation of the stomach.

METHOD

The experiments were carried out on 47 cats which were under urethan anesthesia (1.5-2 g/kg intraperitoneally).

As was previously established, urethan, selectively blocking the activation of the waking state, leaves intact the central apparatus of the alimentary system [10]. This circumstance made it possible to compare the mechanisms of ascending activation of the cortex in the state of hunger and with mechanical irritation of the stomach.

As a rule the experiments were conducted on animals after 24-h fasting. In certain experiments the animals were fed to complete satiation an hour before the injection of the anesthetic.

We exposed the surface of the skull and recorded the EEG by means of steel needle electrodes. The action currents were derived both by the bipolar method (interelectrode distance was usually 3 mm) and unipolarly. In the latter cases the indifferent electrode was fastened over the frontal sinuses along the middle suture. The EEG was recorded on a 10-channel electroencephalograph made by the "Alvar-Electronic" Company.

Mechanical irritation of the stomach was accomplished by a rubber balloon which was inserted into the stomach through an incision in the esophagus on the neck. The degree of inflating the balloon in the stomach was recorded by a tonometer in mm Hg.

RESULTS

As was already reported [10], the bioelectrical activity of the cerebral cortex of cats fasting for one-two days was expressed differently in the anterior and parieto-occipital areas. Whereas in the anterior areas of the cerebral cortex, which include the sensorimotor centers, a high-frequency, low-amplitude activity (desynchronization reaction) was recorded, in the parieto-occipital leads we observed slow high-amplitude waves characteristic for the state of

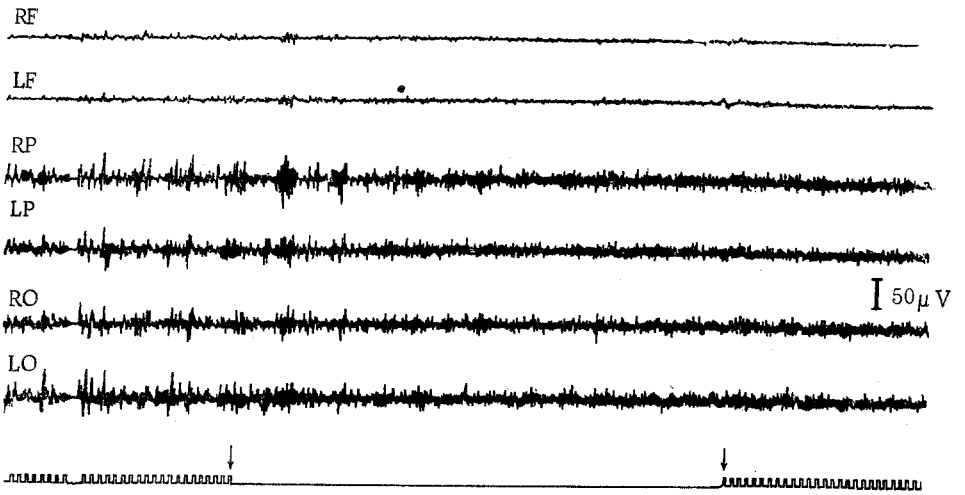

Fig. 1. Changes in the EEG of a fasting animal upon inflation of a balloon (pressure 20 mm Hg) in the stomach. The arrows indicate the beginning and end of inflating the balloon in the stomach. RF) Right frontal area; LF) left frontal; RP) right parietal; LP) left parietal; RO) right occipital; LO) left occipital. Time marker, 1 sec.

anesthesia. Against this background inflation of the balloon in the stomach to a pressure of 20-30 mm Hg evoked generalized desynchronization in all areas of the cortex (Fig. 1). Here we noted a drop in the amplitude of the currents also in the frontal areas of the cortex, which was already activated by the state of hunger. The latent period and the duration of this reaction depended on the force of the irritation. It is necessary to note that the initial EEG was frequently restored even with continued irritation of the stomach. In certain experiments vomiting was observed under these effects.

A similar effect of generalized activation of the EEG in response to mechanical irritation of the stomach was also demonstrated in animals fed before the experiment. However, after ingestion of food an appreciable increase of the threshold of irritation leading to changes of the EEG was observed.

A similar picture of generalized activation of the cerebral cortex of animals under urethan anesthesia was observed upon mechanical or electrical irritation of the vagus nerves (in the neck region) and also when hypertonic solutions of sodium chloride were injected into the stomach. These experiments indicated that mechanical irritation of the gastric mucosa evoked a generalized cortical activation which differed in its character from regional activation of the anterior areas of the cortex caused by a state of physiological hunger.

All this permits the assumption that the system of ascending activating effects on the cerebral cortex in mechanical irritation of the stomach differs from the corresponding process in "hunger" activation.

For analysis of the ascending activation of the cerebral cortex arising upon mechanical irritation of the stomach, chlorpromazine was used in subsequent experiments. It is known that chlorpromazine has a selective effect on the adrenergic substrates of the reticular activating system [1].

As result of these experiments it was demonstrated that after injecting the animals with a solution of chlorpromazine (5 mg/kg), mechanical irritation of the stomach at a pressure even appreciably exceeding the threshold pressure did not evoke a generalized activation of the cortex, although "hunger" activation of the anterior regions of the cortex appeared as usual (Fig. 2). The presence of activation of the anterior cortex after injection of chlorpromazine, associated with the state of physiological hunger, and the absence of generalized activation of the cortex in response to mechanical irritation of the stomach permits us to consider that these two forms of ascending effects on the cerebral cortex are accomplished by different apparatuses of the subcortex. The chlorpromazine block of activation of the cortex with mechanical irritation of the stomach indicates the participation of primarily adrenergic activating apparatuses of the reticular formation of the brain stem in its accomplishment.

The last series of experiments was carried out to determine the afferent pathways along which ascending activation of the cortex is accomplished in response to mechanical irritation of the stomach. For this purpose mechanical

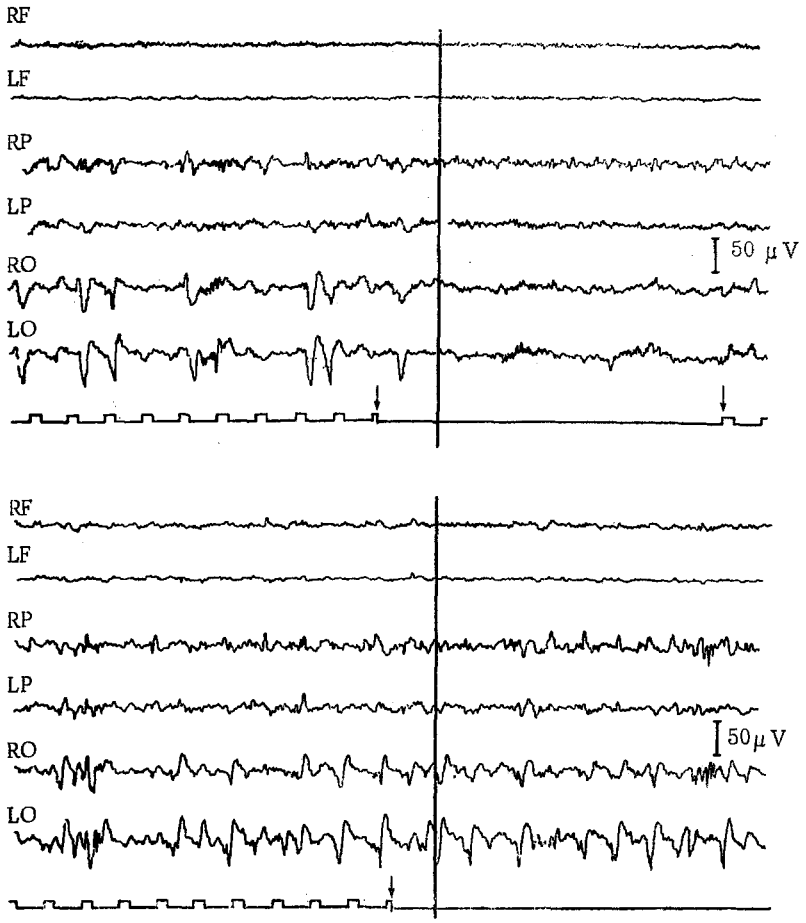

Fig. 2. Change of the EEG in response to mechanical irritation of the stomach (pressure 40 mm Hg) before (top) and after (bottom) injection of chlorpromazine (5 mg/kg). Designations are the same as in Fig. 1.

irritation of the stomach was done after transecting both vagus nerves at the neck or the spinal cord at the level of the I cervical vertebra.

The experiments showed that activation of the cerebral cortex in response to mechanical irritation of the stomach was retained both after transecting the vagus nerves with an intact spinal cord and with transecting of the spinal cord with intact vagus nerves. These experiments permit the conclusion that activation of the cerebral cortex in mechanical irritation of the stomach is accomplished along the vagus nerves and sensory pathways passing through the spinal cord.

On the basis of these experiments we can assume that ascending activation of the cerebral cortex in mechanical irritation of the stomach is formed as a type of biologically negative protective reaction. Apparently the mechanism of ascending activation of the cortex in mechanical irritation of the uterus [9] and in nociceptive irritation [1] is such as this. The generalized ascending activation of the cortex, which occurred in all these cases, reflects a state of general tension of an organism and is formed on the basis of adrenergic mechanisms, which are selectively blocked by chlorpromazine.

As our experiments demonstrated, mechanical irritation of the stomach induces changes in the EEG which differ from those which are observed when food is introduced to the stomach by natural or artificial feeding. All this enables us to consider that mechanical irritation of the stomach cannot be used for studying the mechanisms of satiation. Diffuse activation of the cortex in mechanical irritation of the stomach is, apparently, an expression of an unpleasant, developing nauseous state, since vomiting frequently occurs.

On the basis of our experiments and the data in the literature [4, 11], we can consider that generalized activa-

tion of the cerebral cortex in mechanical irritation of the stomach is accomplished primarily by the adrenergic apparatuses of the reticular formation of the brain stem.

The experimental data obtained confirm the notion of P. K. Anokhin concerning the specific character of multiple ascending activating effects of the subcortical apparatuses on the cerebral cortex.

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