GASTRIC MECHANORECEPTOR REFLEXES BEFORE AND AFTER HEMIDECORTICATION

S. S. Musyashchikova

Receptor Physiology Laboratory (Head – Full Member of the Academy of Medical Sciences of the USSR, Professor V. N. Chernigovsky) and the I. P. Pavlov Laboratory of Pathologic Physiology (Head – Professor V. S. Galkin), the I. P. Pavlov Institute of Physiology (Director – Academician K.M. Bykov) of the Academy of Medical Sciences of the USSR, Leningrad

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The present work was undertaken with a view to elucidate the role of the cerebral cortex in the unconditioned reflex activity of interoceptors.

The work of V. N. Chernigovsky [13] and collaborators [3, 5, 8] has shown that interoceptor reflexes to circulation are greatly enhanced in decerebrate animals. Respiratory reflexes are inhibited by decerebration (section at the inter-collicular level). It has been established that the cerebral cortex exerts a regulatory effect on visceral reflexes to changes in circulation and respiration [4] and in skeletal musculature [2, 6]. According to the data in the works cited, the regulatory action of the cortex is, in the case of some visceral reflexes stimulating, in others – inhibitory. In critical experiments the inhibitory effect of the cortex is mainly observed.

It was decided to investigate the changes in interoceptor reflexes in a series of experiments, using the method of partial decortication.

Photo-recording of cutaneous galvanic reflexes to gastric distention was used as a test of reflex activity. The cutaneous galvanic reflex is widely used both clinically and experimentally in man as an index of vegetative reactions. But only a small number of works [7, 11, 12] have been devoted to the subject in the case of warm-blooded animals.

EXPERIMENTAL

Experiments were performed on cats with gastric fistulas. The skin potentials were led off in two ways: silver electrodes were placed on the soft foot-pads of the hind limbs; one electrode was placed on the foot-pad, the other on the skin of the hind leg (shin). A piece of cotton wool soaked in physiologic solution was placed between the electrode and the animal's skin. The cutaneous potentials were recorded by a mirror galvanometer (type M-21). The galvanometer readings were recorded on photosensitive paper on an electrokymograph. The potential differences were measured in millivolts (made possible by using a compensatory device attached to the galvanometer).

The animals were familiarized with the experimental conditions over a period of several days. They were laid down on a mat, and the hind legs were fixed by an assistant, since movements affected the changes of potential. Half an hour before the beginning of the experiment a rubber balloon was inserted into the stomach through the fistula; the balloon was connected with a rubber bulb and a mercury manometer. The skin galvanic reflexes to gastric distension were elicited by inflating the balloon. Reflexes were recorded at intra-gastric pressures of 40, 60 and 80 mm of mercury. The stimuli were applied at 5-7 minute intervals.

RESULTS

Skin galvanic reflex responses to gastric distention in cats with intact nervous system.

The investigation of skin galvanic responses in cats is complicated by the fact that the potential differences of the skin are unstable and inconstant. Therefore, the original potential level in the record appears not as a straight line as in the case of man and dogs, but as an undulating curve. The components of this curve reach 1-5 mv. These peculiarities complicate the course of cutaneous galvanic reactions in cats and the analysis of reflex activity is thus made more difficult.

The reflex response of the skin to gastric distention was most frequently expressed by increased negativity of the foot-pad with respect to the shin skin potential, which was reflected by a downward deflection of the galvanometer with respect to the base line (Fig. 1, c). The reverse effect was also observed in response to stimulation (Fig. 1, a and b). The reactions were different in different animals; three types of response could be distinguished: 1) gastric stimulation was accompanied by a single change in potential, recorded as a deflection from the initial level (Fig. 1, a); 2) the cutaneous galvanic reflex appeared as fluctuations of skin potentials with greater amplitude and frequency than those observed in the original background (Fig. 1, b); 3) the cutaneous galvanic response appeared both as changes in the potential differences and simultaneous increase in amplitude and frequency of oscillations as compared to the original background (Fig. 1, c).

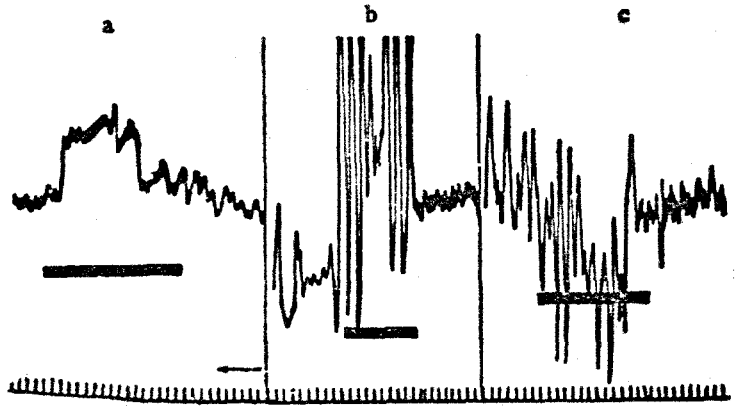

Fig. 1. Cutaneous galvanic response to gastric distention (pressure 60 mm of mercury).
a) cat Dymka, b) cat Belaya mordochka; c) cat Murzik. Records from above down: skin potentials, stimulus marker, time marker 5 seconds.

The type of reaction in a given animal was constant throughout a series of experiments. A response could usually be observed at balloon pressure of 40 mm of mercury. The response increased with growing distention of the stomach. This was observed with all types of cutaneous galvanic reactions. In those experiments where it was of the second type increased stimulation led to increased enhancement of the amplitude and frequency of the oscillations as compared to the background.

Partial limitation of the receptor field was used in an attempt to find the source of variability of the reflex response to gastric distention This was achieved by painting the gastric mucosa with a 2-3% solution of cocaine. Under these conditions it was found that the skin galvanic reaction did not disappear. Only in one of 18 experiments did the reaction fail to appear even in response to strong stimulation (pressure 80 mm of mercury). In all the other cases, the responses were definite but their magnitude was somewhat less than in the normal. In some experiments the threshold was raised after anesthesia and no response was seen to pressure of 40 mm of mercury. As can be seen from Figure 2, when the gastric mucosa was painted with cocaine, the amplitude of the potential difference oscillations decreased sharply, the background was smoothed out and the

reaction followed the third type of response. Regardless of the type of response prior to anesthesia the reflexes after anesthesia consisted of a shift in the potential differences from the original level and of small oscillations.

Analysis of the results of this series of experiments provides grounds for supposing that the decreased reflex reactions and increased thresholds are connected with elimination of gastric mechanoreceptors. When cocaine is introduced into the stomach it first of all affects the receptor endings situated in the mucosa, but on penetrating further it can also affect the mechanoreceptors of the muscle and serous layers. As the result the magnitude of the reaction decreases and the threshold rises, while at the same time the fluctuations of potential difference in the original background are considerably diminished and the reflex response is made up of a simultaneous shift of potential difference from the original level and its fluctuation.

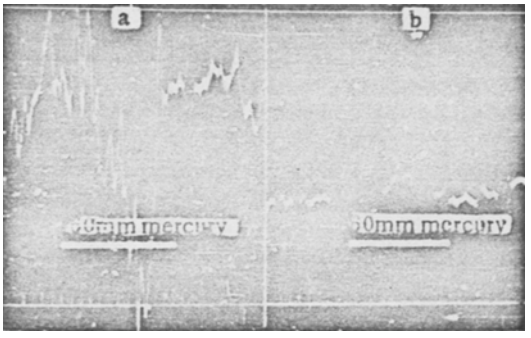

Fig. 2. Cutaneous galvanic reflex response to gastric distention (pressure 60 mm of mercury) after partial elimination of gastric receptors.
Cat Krasivy.
a) before anesthesia of stomach; b) after anesthetising stomach with cocaine. Record from above down same as Fig. 1.

Cutaneous galvanic reflex responses to gastric distention in cats after hemidecortication.

The reactions described above were studied in cats with intact cortex over a period of 3-4 months. Sixteen to thirty-five experiments were carried out on each animal prior to operation. When the background reactions had thus been determined the cats were subjected to extirpation of the cortex from the left cerebral hemisphere. The cortex was completely removed from the occipital, parietal, most of the temporal and frontal areas. The basal portion of temporal cortex was spared. Five animals were used.

The behavior of the animals post-operatively corresponded to descriptions reported in the literature [1, 9, 10]. Marked incoordination of movements was noted in the first few days after operation. The right hind limb was weak and did not participate actively in locomotion. In response to calling or the sound of dishes indicating feeding time, the operated cats performed rotary movements from right to left round themselves prior to approaching the source of the sound. With time the phenomena described subsided and after 2 months, it was difficult to distinguish on cursory examination the operated animals from healthy ones.

The cutaneous galvanic reactions to gastric distention were tested from the 7th post-operative day onward. The results of the experiments showed that 7-10 days after operation the reflexes under investigation were depressed. They appeared only in response to strong stimulation (pressure 80 mm of mercury) and their magnitude was diminished compared to the normal. Weaker stimuli (pressure 40-60 mm of mercury) elicited no response. Gradual restoration of the reflexes and lowering of the thresholds were observed during subsequent days. After 3 weeks or a month, their magnitude exceeded that observed prior to operation.

As can be seen from Figure 3, one month post-operatively the reflexes had increased. The threshold had become lower: if prior to operation the animal showed no response to gastric distention equivalent to 40 mm of mercury (Fig. 3, a) one month after operation the same strength of stimulation elicited quite a definite change in cutaneous potential difference (Fig. 3, b).

The reflexes in operated animals were kept under observation for $2^1/_2$ years. The reflexes became normal after 6-8 months, their magnitude not exceeding the original value. Figure 3, c represents an experiment performed 7 months post-operatively.

The background galvanogram was preserved after operation. The potential differences were inconstant in the same way as pre-operatively.

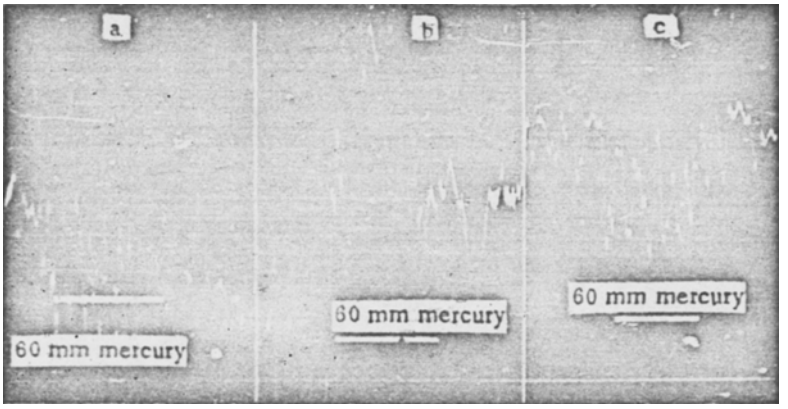

Fig. 3. Cutaneous galvanic reflex responses to gastric distention (pressure 60 mm of mercury) before and after extirpation of cortex. Cat. a) before operation; b) one month after extirpation of cortex from the left hemisphere; c) 7 months after operation. Records from above down the same as in Fig. 1.

DISCUSSION OF RESULTS

The material obtained indicates that hemidecortication leads to changes in interoceptive reflexes to stimulation of the gastric mechanoreceptors. Seven to ten days post-operatively the reflexes were depressed; their magnitude was small and the threshold high. Later on they increased and exceeded the initial background.

The first phase of the observed changes can be explained by the inhibition of reflexes seen in the early post-operative period being du · extensive and gross cerebral trauma. As the healing proceeds the reflexes are restored and subsequently (after a month) exceed the original. It can thus be concluded that under normal conditions the cerebral cortex inhibits the interoceptive skin galvanic reflex under investigation. If the fact that decerebration is associated with increased interoceptive reflexes, as shown by other indicators, is taken into account, the observed inhibitory effect of the cerebral cortex on the interoceptive reflex under investigation becomes a particular case of cortical inhibition of many unconditioned reflexes.

Further restoration of the reflex to the original values evidently occurs with the help of the compensatory mechanisms of the intact cerebral hemisphere.

SUMMARY

Galvanic skin reflexes to the distention of the stomach were studied on cats before and after hemidecortication.

From 7 to 10 days after extirpation, reflexes were depressed owing to the trauma after-effect. They increased sharply after a month, the thresholds having dropped. From 6 to 8 months after extirpation, reflexes attained the original level. Increase of the reflexes under study in the experimental animals may be due to the partial elimination of the inhibitory effects of the cerebral cortex. Restoration of the reflexes is due to the compensatory mechanisms of the intact hemisphere.

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