ELECTROPHYSIOLOGICAL CHARACTERISTICS OF THE ACTION OF FOREIGN BLOOD UPON SPLENIC INTEROCEPTORS

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When investigating the mechanism establishing the interoceptive reflexes, great significance must be attached to clarification of the roles played by the individual links of the central nervous system leading to the completion and fulfillment of the reflexes.

According to the data of V. N. Chernigovsky [10] and his co-workers – V. A. Lebedeva [7], G. A. Kovaleva [4], as well as V. A. Alekseev [1], in decerebrate animals, when interoceptors of the internal organs are stimulated, there are vasomotor and respiratory responses but no basic or even substantial alterations occur. It should be noted that with high decerebration, when the transection is made superior to the anterior colliculi of the corpora quadrigemina, the reflex arc coming from the interoceptors does not appear to be markedly affected.

V. N. Chernigovsky in analyzing his results came to the conclusion that the principal prerequisite for the preservation of the interoceptive reflexes is the intactness of the visual colliculi.

Of great interest are the studies of R. S. Vinitskaya [2, 3] who showed the presence of a regulating influence within the hypothalamic region, this determining the intensity of the interoceptive reflex response.

The present investigation used the method of recording bioelectric potentials within certain subcortical areas as a partial index of the reaction of the organism to interoceptive irritations produced by irrigating the spleen with foreign species blood.

EXPERIMENTAL METHODS

The experiments were performed on dogs as short experiments. Under ether anesthesia, the skull had trephine openings made in it, ebonite plugs being used to close them and electrodes being inserted through them. As electrodes silver wires were used, their diameter being 0.2 mm and their manufacture following the method of A. B. Kogan [5].

The precise place of insertion of the electrodes was determined by studying anatomic preparations of the fixed brain with the additional aid of serial frontal sections, as well as by histological studies of the areas where the insertions were actually made.

The bioelectrical activities of the subcortical regions were registered by means of a single channel oscillograph recording on photopaper moving 2.8 cm per second. The sensitivity of the instrument – 2.8 μv for every 1 mm declination of the ray.

The experiments were conducted in a screened chamber.

From the moment of inserting the electrodes into the brain tissues to the beginning of recording of the potentials in the individual experiments, from 1.5 to 2.3 hours would elapse. This greatly exceeded the time needed to free the subcortical EEG's from the currents of injury (10-15 minutes) as established by A. B. Kogan [6].

The experiments were begun only after stabilization of the background of electrical activity.

The spleen circulation was also isolated under ether anesthesia, by the method of V. N. Chernigovsky. The foreign blood used came from rabbits, the citrated blood being introduced into the perfusate from a vessel suspended on the wall of the oscilliographic chamber and allowed to flow for 5-10 minutes, thus irrigating the spleen.

The bioelectric potentials of the subcortical structures were correlated with kymographic recordings of the arterial pressure and were taken before and during perfusion as well as well as 5, 10 and 20 minutes after the spleen had been perfused with the foreign blood.

EXPERIMENTAL RESULTS

In the experiments the electrical activities of the visual colliculi (anterior, medial and ventral nuclei as well as the hillock), the subcollicular region, the caudate nucleus, the corpora quadrigemina and the pons Varoli were recorded.

It was established that perfusion of the isolated spleen by the V. N. Chernigovsky method using foreign (citrated rabbit) blood led to numerous alterations in the enumerated structures.

The changes were greatest in the electrothalamograms showing themselves in the increased amplitude of the slow waves – 3-7 cps constituting their specific characteristic (Experiments Nos. 90, 97 and 100), occasional discharges of sharp, spike-like negative waves (Expt. No. 90) slow waves with sharp peaks (Expt. Nos. 95 and 97), and voltage increases of all components of the electrothalamogram.

These changes coincided with the beginning of the perfusion, the electrothalamogram quieting by its end (Fig. 1).

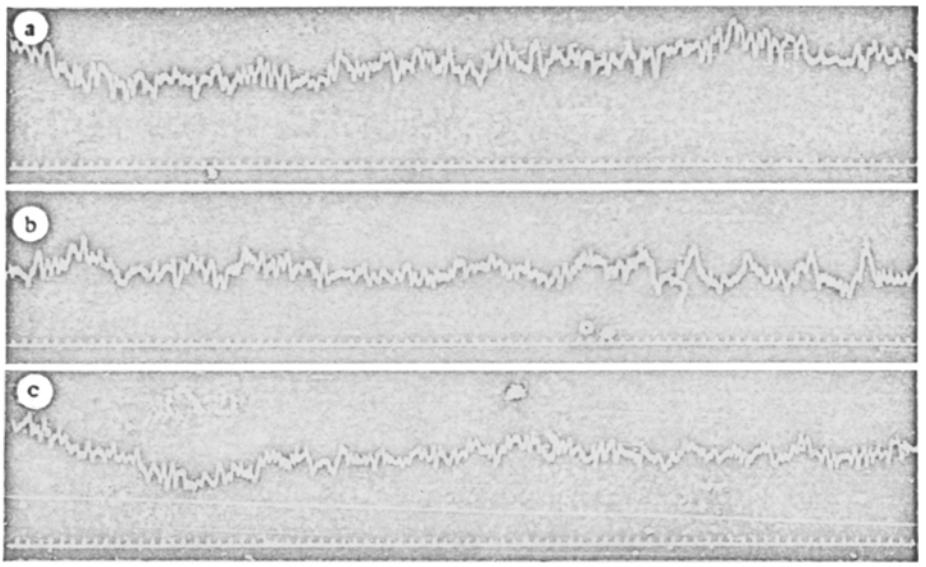

Fig. 1. Bioelectrical activity of the thalamic region in the dynamics of stimulation produced by foreign blood stimulating the spleen interoceptors (Expt. 95, October 12, 1952). Dog weighed 22 kg.
Tracing records electrical activity of the ventral nucleus of the visual colliculus; a) before perfusion of spleen with foreign blood; b) during irrigation; c) at end of perfusion. Time marker (1/20 second).

In the instances described, the introduction of the rabbit blood into the perfusing fluid led to a sharp reaction on the part of the cardiovascular system, the response having a pressor-depressor character.

In those experiments where the background activity was characterized by low amplitude bioelectric waves (Expts. Nos. 97a, 105, 109 and 110), perfusion with foreign blood did not provoke activity changes. The hemodynamic response in these cases was also feeble.

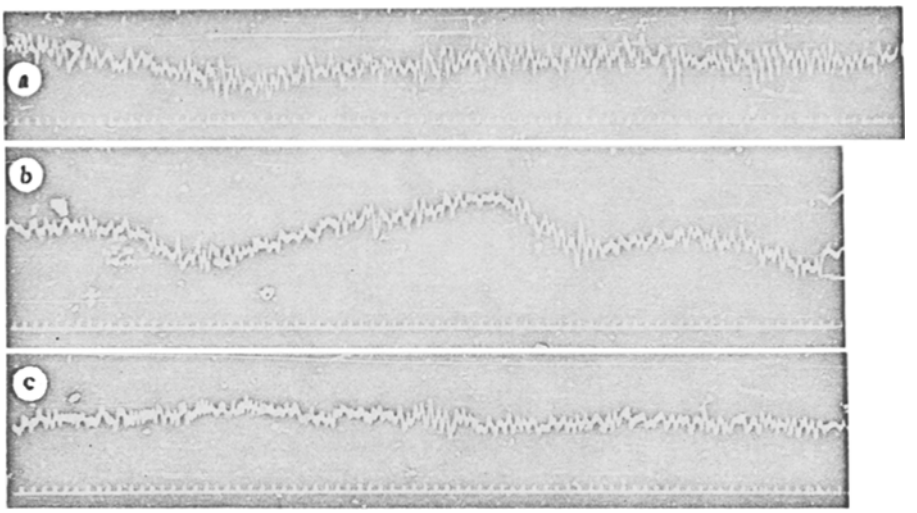

Fig. 3. Bioelectric activity of the pons Varoli in the dynamics of the effect of foreign blood perfusion upon the splenic interoceptors (Expt. No. 95, December 10, 1952). Dog weighed 22 kg.
Record of electrical activity: a) before irrigating spleen with foreign blood; b) from the beginning of the irrigation; c) at end of irrigation.

Under the conditions of our set-up, the experiments failed to show a strict parallelism in the bioelectrical alterations of some of the brain regions studied. Thus, perfusion of spleen with foreign blood increased the bioelectrical activity of the pad of the visual colliculus in some instances when the head of the caudate nucleus was completely unreactive, and vice versa.

In one of our experiments (No. 110a) the blood appeared to have no influence on the nature of the thalamogram, yet the potentials from the nucleus griseus revealed a sharp increase in amplitude (7 and 8 fold), going on into an "electric storm".

Along with this the complex method of potential recordings has succeeded in establishing the presence of a single direction of the EEG changes of the central region of the thalamus and the grey matter in the left wall of the third ventricle (marked rise in electric potentials along with a pressor arterial response) which, in all likelihood, indicates a single nerve process underlying the activity.

All this gives us the right to postulate that stimulation of splenic interoceptors with foreign blood under the conditions of the perfusion experiment leads to complex functional alterations in all the divisions of the brain investigated. This is reflected by the EEG tracings taken from the brain divisions studied.

The changes met with in association with interoceptor stimulation of the spleen by means of foreign blood perfusion clearly reveal electrical activity in the thalamic region with frequent spiking, indicating that they are not only a reflection of local changes associated with synaptic stimulation (voltage alterations of the basic components of the tracing) but also a reflection of afferent impulses going through the visual colliculi to other divisions of the brain. In this last instance we are discussing that type of cerebral activity that V. S. Rusinov [9] calls "running waves of excitation" and which manifests itself by axon-like discharges.

Putting together the electrophysiologic pictures obtained from the various subcortical levels, we allow ourselves to suppose that the afferent impulses aroused by the action of the foreign blood upon the splenic receptors direct themselves to the subcortical regions, placing the different levels at times into reciprocal, at times into synergistic correlations, thus creating a whole subcortical mosaic (stimulation of some regions-inhibition of others) which basically will determine the response of the organism to the interoceptor stimulation.

The use of stereotactic instruments combined with the principle of simultaneous recording of various potentials from the subcortical regions, analogous to the method worked out by M. N. Livanov for the cortex of the brain [8], will permit the answer to this whole question to be given in detail.

It is interesting to observe that in those instances where the EEG's showed signs of returning to base level activity after the perfusion, there was also observed a marked tendency for restoration of the arterial blood pressure (Fig. 2).

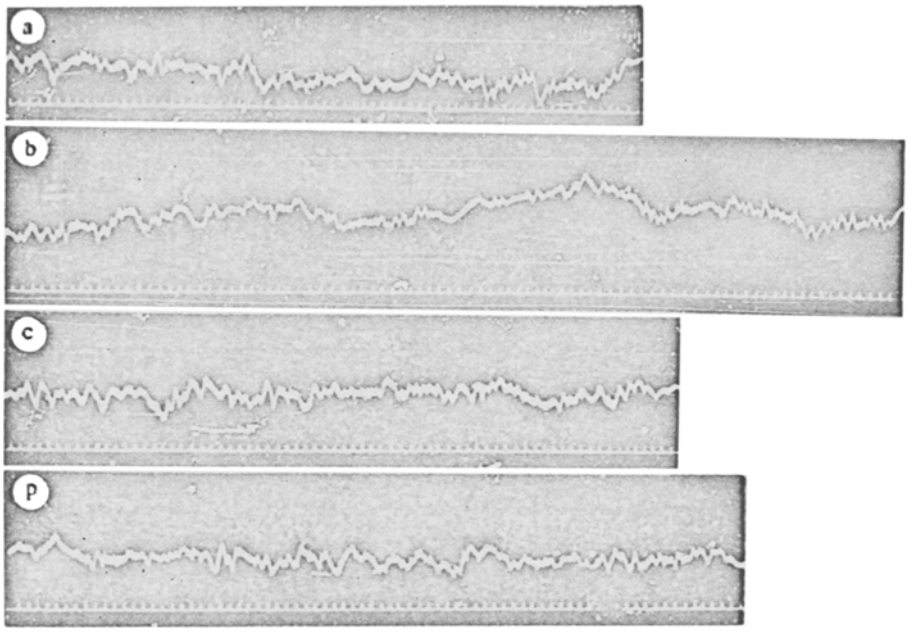

Fig. 2. Bioelectric activity of the thalamic region in the dynamics of effect of perfusion with foreign blood of the spleen interoceptors (Expt. No. 100, December 21, 1952). Dog weighed 9 kg.
Tracing recorded activity of medial hillock: a) before perfusion of spleen; b) beginning of perfusion; c) 10 minutes after the perfusion; d) 20 minutes after the perfusion.

During splenic irrigation with the heterophilic blood the EEG of the nucleus griseus also sharply changes its character.

The usual picture of low amplitude rhythm of 20 cps waves is replaced by a slow 2-6 cps rhythm, with a voltage of from 6 to 35 μv, while by the end of the perfusion, after the "electric storm" – single slow waves with a period from 0.5 to 1 second and a voltage of 70-75 μv, alternate with waves having a rhythm of 4-5 cps.

It must be noted that in these experiments where the electrodes were sunk into the nucleus griseus we observed a more marked response to the foreign blood, which confirms the conclusion of R. S. Vinitskaya [2] as to the influence exerted by the hypothalamic region upon the intensity of the interoceptive reflexes.

Of interest were the bioelectric potential alterations in the caudate nucleus (head) as the dynamics of splenic irritation with foreign blood unfolded. Here, as with the potentials of the thalamic region, there was observed a correlation between sharp responses of the EEG with the hemodynamic status.

At the same time, comparison of EEG's from the pons Varoli with kymograms of the arterial pressures during the period of activity by the foreign blood perfusion fails to establish any consistent correlation. Here there could often be seen EEG's changing in the absence of hemodynamic response to the heterophilic blood (Fig. 3).

Accepting as fact that electrophysiologic changes reflect nerve processes, we attempted to record within a single experiment the simultaneous bioelectric potentials of various regions of the brain, the effort being to analyze any possible intercorrelations between the subcortical regions being established while the splenic interoceptors were being stimulated by the foreign blood.

As we had only a single channel installation, we could not make the recordings truly simultaneous. We were forced to record the waves in sequence, at intervals of 5-10 seconds, switching the current at the distributor bar.

SUMMARY

Electrodes were placed into precisely predetermined subcortical levels of dogs during short experiments. Their spleens were then perfused with rabbit blood after this organ had been humorally isolated. The EEG tracings were taken simultaneously with arterial blood pressures.

It was noted that the most pronounced changes were caused in cases where the hemodynamic responses were also most rapid.

The theory is advanced that the afferent stimuli from the splenic interoceptors sets up a regular mosaic of reciprocal and synergistic subcortical afferent waves of stimuli, the sum total of these determining the response of the organism to the stimulus.

LITERATURE CITED

[1] V. A. Alekseev, Interoceptors of the Pancreas.* Dissertation, Kirov, 1943.

[2] R. S. Vinitskaya, Byull. Ekspti. Biol. i Med. 1952, Vol. 34, No. 9, pp. 5-10.

[3] R. S. Vinitskaya, Byull. Ekspti. Biol. i Med. 1954, Vol. 37, No. 3, pp.3-8.

[4] G. A. Kovaleva, Influence of Functional States of the Central Nervous System Upon Interoceptive Processes.* Dissertation, Leningrad, 1949.

[5] A. B. Kogan, Procedures for Series Application of Electrodes for the Purpose of Taking Potentials and Stimulating the Brain,* Moscow, 1952.

[6] A. B. Kogan, EEG studies of the Central Mechanisms of Some Complex Reflexes* Moscow, 1949.

[7] V. A. Lebedeva, Some Peculiarities of the Gastrointestinal Interoceptors* Dissertation. Leningrad, 1947.

[8] M. N. Livanov, and V. M. Ananiev, Fiziol. Zhur. SSSR, 1955, Vol. 41, No. 4, p. 461.

[9] V. S. Rusinov, Voprosy Neirokhirurg., 1953, No. 1, p. 3.

[10] V. N. Chemigovsky, Afferent Systems of Internal Organs,* Kirov, 1943.

* In Russian.