THE ELECTROPHYSIOLOGICAL ANALYSIS OF THE ACTION OF ANTIGENS ON ANGIOCEPTORS

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In our previous research we found that the injection of an antigen into the isolated carotid sinus leads to the production of specific antibodies, in spite of the removal of the depot of antigen after five minutes [3, 4, 5]. These findings were confirmed by the investigations of E. A. Tatarinov [9], V. A. Tychinin [10] and B. G. Avetikyan [1].

At the same time, G. V. Shumakova [11], and Z. M. Prusakova [8] point out that the production of antibodies in this form of immunization takes place only in the presence of resorption of the antigen. A. D. Ado [2] considers that antigens have the power to cause stimulation of the receptors of the carotid sinus only when immunological reactivity is modified, and in the absence of such a modification they do not possess this power.

In this worker's opinion, an antigen cannot reflexively cause the production of antibodies, for it does not have the power to cause stimulation of the receptors on first contact.

We have shown that the intradermal injection of vaccines of different microorganisms causes stimulation of the receptors of the skin, as a result of which a stream of afferent impulses passes along the sensory fibers [6]. Pathogenic microorganisms of the enteric group stimulate the receptors of the carotid sinus and cause changes in the action potentials in the carotid sinus nerve [7].

In the present communication we describe the changes in the action potentials in the carotid sinus nerve during the action of staphylococcal, whooping cough, and Escherichia coli antigens on the receptors of the carotid sinus.

METHOD

Experiments were carried out on dogs. The carotid sinus nerve was isolated under hexobarbital anesthesia and was surrounded by a ligature. All the major vascular branches, except the common carotid artery, were ligated 1-1.5 cm from the bifurcation. The carotid sinus nerve was placed in a rubber tube in which electrodes were inserted and affixed in order to assure reliable contact. The action potentials were recorded on a loop oscillograph. Type 2-kub-2 amplifiers and the animals were placed in a screened room, providing reliable protection from electrostatic and electromagnetic effects.

Antigen, in a dose of 0.3-0.5 ml, was injected through the common carotid artery. The vaccines used were prepared by the Rostov Institute of Vaccines and Sera and contained 4×10^9 bacterial cells/ml.

Four series of experiments were performed, with 10-12 animals in each.

RESULTS

The initial background of the action potentials in the carotid sinus nerve showed characteristic discharges of rapid waves, which followed different intervals of time (0.5-3.25 sec) in individual animals. The amplitude of these waves reached 5-20 μv. In each discharge, from 20 to 40 waves were counted. In the intervals between the discharges the bioelectrical activity of the carotid sinus nerve was weak.

In the first series (12 experiments) the action of staphylococcal vaccine was studied. Injection of the vaccine in all the experiments caused changes in the bioelectrical activity of the carotid sinus nerve, but of varying degree. As a rule (nine experiments) the amplitude of the waves of potential forming a discharge was increased 1.5-2 times and reached 8-40 μv. The number of waves in the discharge increased two- or three-fold, to as much as 90 waves per second. The amplitude of the interdischarge potentials was increased, sometimes to reach the magnitude of the original background discharge waves. In the majority of cases the reaction developed after 0.5-1.5 min and occasionally it was immediately after injection of the vaccine. Normalization of the action potentials was observed after 3-10 min. In the remaining three experiments, after injection of the

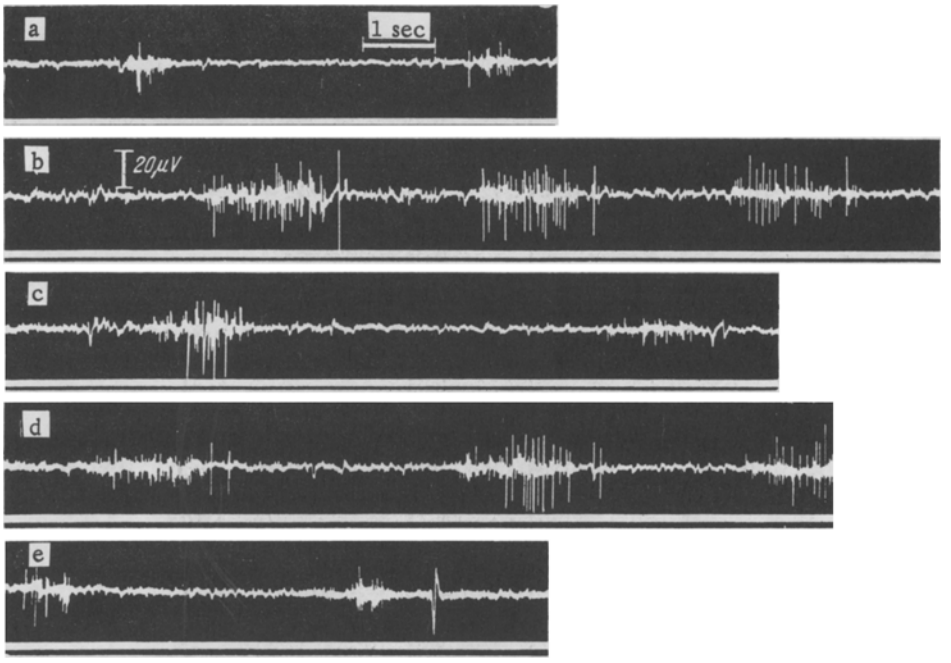

Fig. 1. Electroneurogram of the carotid sinus nerve after the action of staphylococcal antigen. a—Initial background; b—at the moment of injection of the antigen; c, d, e—1, 2, and 5 minutes after injection of the antigen.

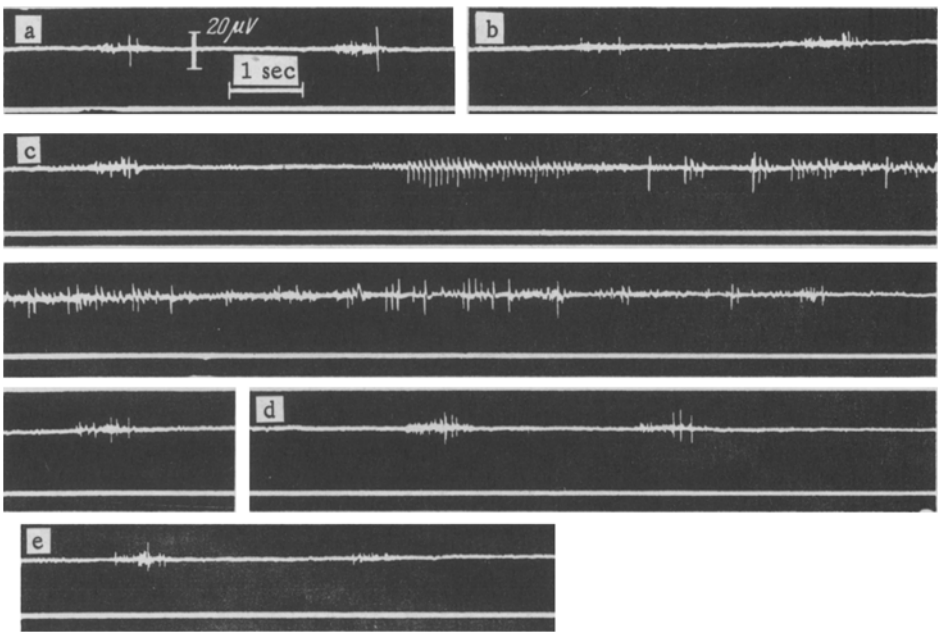

Fig. 2. Electroneurogram of the carotid sinus nerve after the action of whooping cough vaccine. a—Initial background; b—at the moment of injection of antigen; c, d, e—1, 3, and 5 minutes after injection of antigen.

antigen the bioelectrical activity in the interdischarge period was unchanged, but the amplitude of the discharge waves increased to 50% of the initial magnitude.

The change in the character of the flow of impulses after injection of staphylococcal antigen into the carotid sinus can be seen from the photocopies of the electroneurograms given below (Fig. 1).

In the second series (12 experiments) the bioelectrical activity of the carotid sinus nerve was studied during the action of whooping cough antigen on the recep-

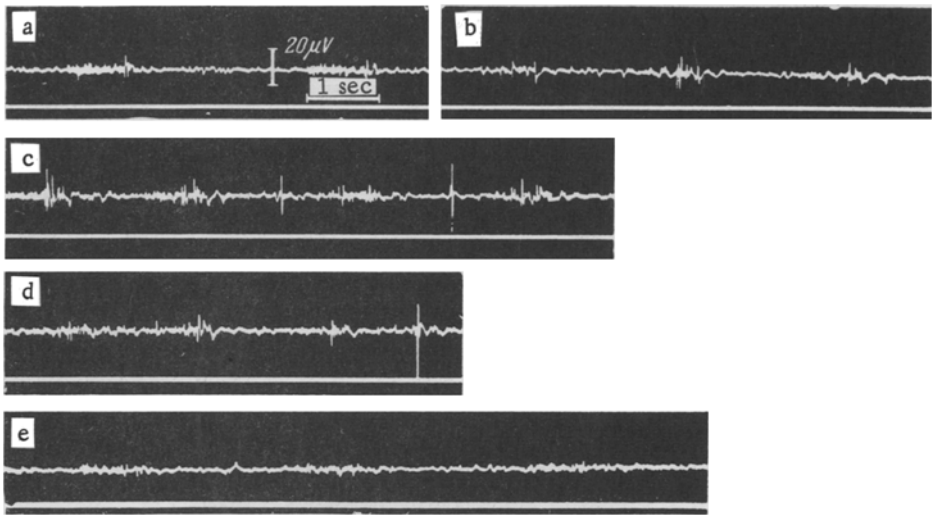

Fig. 3. Electroneurogram of the carotid sinus nerve after the action of E. coli vaccine. a—Initial background; b, c, d, e—1, 3, 5, and 10 minutes after injection of antigen.

tors of the carotid sinus. Before injection of the antigen the ordinary flow of impulses in the carotid sinus nerve, as described above, was recorded.

After injection of the vaccine the character of the action potentials of the carotid sinus nerve was changed: Monophasic or, more often, biphasic waves with sharp apices were recorded, the amplitude of which reached 8-25 μv. In some cases groups of waves appeared, with a frequency of 10 to 18 per second. The amplitude of these waves reached 7-14 μv. The reaction lasted for two or three minutes and the action potentials then returned to their initial state (Fig. 2).

The electrophysiological characteristics of the reaction of the carotid sinus nerve in this case differed from those of the reaction observed in response to the action of staphylococci on the receptors of the carotid sinus (see Figs. 1 and 2).

In the third series (10 experiments) the bioelectrical activity of the carotid sinus nerve was studied during the action of E. coli antigen. The injection of this antigen into the carotid sinus caused little change in the action potentials of the carotid sinus nerve. In some cases the character of the groups of discharges was changed, and occasionally solitary monophasic and biphasic waves appeared (Fig. 3).

The study of the character of the changes in the potentials in the carotid sinus nerve after injection of physiological saline into the carotid sinus (fourth series of experiments) enabled the effect of changes of pressure due to the injection of that particular volume of fluid to be estimated. When the common carotid artery was not ligated, the possibility of mechanical stimulation from the injection of 0.3-0.5 ml of fluid was unlikely. Nevertheless, we considered it necessary to perform a series of control experiments in which sterile physiological saline was injected. The injection of physiological saline did not alter the action potentials of the nerve, either at the moment of injection or at different periods thereafter. The character of the oscillograms throughout the whole time after the injection of physiological saline showed no significant difference from that of the initial background (Fig. 4).

Electrophysiological analysis of staphylococcal and whooping cough antigens and of E. coli on the vascular receptors of the carotid zone shows very convincingly that these agents possess the ability to stimulate the receptors of the carotid sinus. The stimulation is transformed into a process of excitation and this excitation reveals itself by a particular type of neurogram. E. coli antigen possesses this property to a lesser degree.

The changes in the action potentials in the carotid sinus nerve cannot be explained by mechanical stimulation of the receptors, since injection of the same volume of physiological saline as a rule caused no changes in the action potentials in the carotid sinus nerve.

It should be mentioned that, during comparison of the electroneurograms recorded after the injection of staphylococcal and whooping cough antigens and, to a lesser degree, E. coli antigen, certain differences are found, as shown by the characteristic changes in the discharges of waves of potential, the configuration of the discharges themselves, and the bioelectrical activity in the intervals between the discharges.

From the results obtained it may be concluded that the quality of the excitation in the receptors is different during the action of different antigens, and that this may, possibly, determine the special features of the reaction of the body to various pathogenic stimuli.

SUMMARY

Staphylococcal antigen produces irritation of the carotid sinus receptors; this is transformed into excitation,

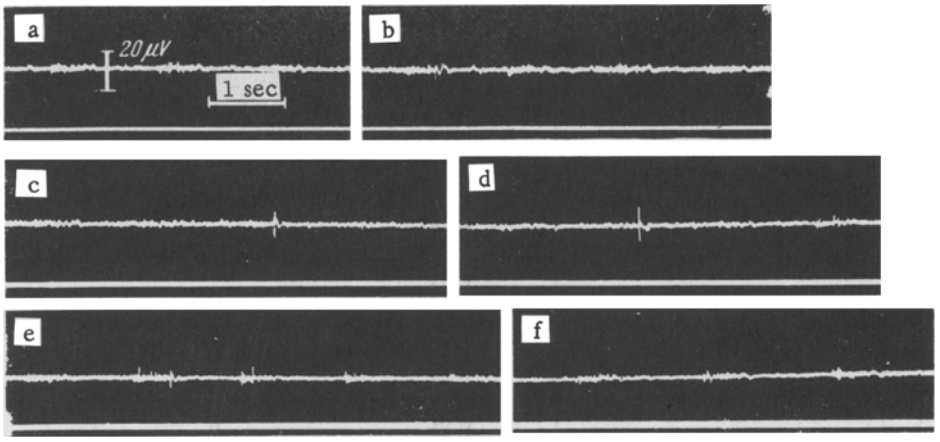

Fig. 4. Electroneurogram of the carotid sinus nerve after injection of physiological saline (control). a—Initial background; b—at the moment of injection of the solution; c, d, e, f—1, 2, 5, and 10 minutes after injection of the solution.

which gives rise to fluctuating bioelectric potentials of monophasic and biphasic character. The discharge period is increased, while in the intervals between the discharges the initial fluctuation of the potentials becomes intensified. Pertussis antigen also irritates the carotid sinus receptors and thus produces in the carotid sinus nerve a flow of impulses changing the normal oscillogram of this nerve. E.coli has a weak ability to irritate the carotid sinus receptors and changes only insignificantly the fluctuation rate of the carotid sinus nerve bioelectric potentials. The variations in the action currents of the carotid sinus nerve, originating from the action of the antigens on the carotid sinus receptors, are independent of any mechanical irritation. Administration of the same amount of physiological saline has no effect on the oscillogram of the sinus nerve.

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*Original Russian pagination. See C.B. translation.