The view that there is a close relationship between rhythmic stimulation and the parabiotic process is becoming increasingly widely held [1, 6, 7]. The excitation wave is regarded as a reversible parabiotic process. From this standpoint, the response reaction of the organ to the rhythmic stimulation depends on which particular phase of the reverse parabiotic reaction coincides with each successive impulse. If the second of a rhythmic series of stimulating impulses coincides with an inhibitory stage of the parabiotic process, a pessimal reaction results. Since each of the successive impulses intensifies the parabiotic process, maintaining it in the inhibtory stage, the pessimal reaction persists over the whole duration of stimulation. The longer the inhibitory phase of the parabiotic process is maintained, the smaller is the frequency which gives rise to a pessimal effect.

In our experiments, when we increased the duration of the stimulating impulses we thereby increased the duration of action of the dc cathode on the excitable substrate, and this, acting as a parabiotic agent, stopped the reverse parabiotic process.

LITERATURE CITED

[1] L. L. Vasilev, Advances in Reflexology and Physiology of the Nervous System,* 1929, Collection 3, pp. 31-42.

[2] N. E. Vvedensky, Excitation, Inhibition, and Narcosis,* St. Petersburg, 1901.

[3] A. G. Ivanov-Smolensky, Systematic Experimental Study of the Ontogenetic Development of the Dynamics of the Human Cerebral Cortex,* pp. 268-278, Moscow, 1940.

[4] A. N. Kabanov, Izvest. Akad. Pedagog. Nauk. RSFSR, 1954, No. 6, 124-126.

[5] M. V. Kirzon, Trans. Sci. Research Inst. Physiol., Leningrad Univ., 1934, No. 14, pp. 34-71.

[6] L. V. Latmanizova, Vvednensky's Laws of Electrical Activity of Excitable Units,* Leningrad, 1949.

[7] A. N. Magnitsky, Proceedings of the Congress in Honor of N. E. Vvedensky,* pp. 23-55. Moscow-Leningrad, 1949.

[8] A. N. Magnitsky and E. B. Perelman, Fiziol. Zhur. SSSR, 25, No. 3, 244-248 (1938).

[9] A. N. Magnitsky and V. D. Turbaba, Fiziol. Zhur. SSSR, 25, No. 3, 249-251 (1938).

[10] I. P. Pavlov, Complete Collected Works,* Vol. 3, Book 2. Moscow-Leningrad, 1951.

[11] V. D. Rosanova Fiziol. Zhur. SSSR, 30, No. 3, 346-356 (1941).

[12] Yu. M. Uflyand, Proceedings of the Congress in Honor of N. E. Vvedensky,* p. 73, Moscow-Leningrad, 1949.

[13] Yu. M. Uflyand and N. A. Shoshina, Fiziol. Zhur. SSSR, 23, 187-201 (1937).

ELECTROPHYSIOLOGICAL PHENOMENA IN NERVES DURING THE ACTION OF ANTIGENS ON SKIN RECEPTORS

A. N. Gordienko, V. I. Kiseleva, B. A. Saakov, and A. V. Leten

From the Chair of Pathol. Physiology (Director: Prof. A. N. Gordienko), Rostov Medical Institute

(Received March 16, 1956. Presented by V. N. Chernigovsky, Member Acad. Med. Sci. USSR)

With each year, more and more experimental evidence of the reflex mechanism of the action of antigens is being published, as well as of the development of processes of infection along these lines (A. D. Speransky, and co-workers, V. S. Galkin, G. V. Peshkovsky and co-workers, and others). Our laboratory has devoted many

* In Russian.

years to the investigation of the reflex mechanism of production of antibodies, and has found considerable evidence supporting its existence. We are, however, unable to find any publications dealing with the physiological analysis of the action of antigens on receptors, and with the path followed by the resulting excitation along the sensory channels. An antigen, in acting on a receptor, causes its excitation. The nature of this excitation may vary, according to the species of microorganism used for the purpose. The fact that specific antibodies are elaborated in response to different antigens is evidence of the specificity of the excitation evoked by the latter. An understanding of this effect may be assisted by an electrophysiological analysis of the processes arising in the receptors as a result of the action of antigens, and of the sensory conductors involved. With this object, we recorded the impulses proceeding through sensory channels from the stimulated receptors.

The electrophysiological study of sensory conductors during the action of antigens on receptors can also provide additional evidence in favor of the assumption regarding reflex elaboration of antibodies.

EXPERIMENTAL METHODS

The experiments were performed on dogs, under henexal anesthesia. The biopotentials were recorded from the auricular and the external saphenous nerves. For this purpose, the nerve was dissected free, and was split up, using a glass rod, into narrow strands, which were fastened to specially designed electrodes. We recorded the biopotentials from these nerves before and after intradermal injection of antigens and of physiological saline (control experiments) into different parts of the ear and the thigh. Amplification of the biocurrents was effected by means of the two-channel equipment 2-KUB-2, made by the Acad. Med. Sci. USSR Factory (1951), in a steel-lined chamber. The recordings were made on a moving strip of oscillographic paper, using a 9-channel oscillograph, made by Siemens and Halske (GDR) in 1951.

The biopotentials were taken from the auricular nerve before and after intradermal injection of typhoid, dysentery, or paratyphoid antigens (0.2 ml) into various parts of the ear. The recordings from the external saphenous nerve were also taken before and after injection of the antigens into the skin of the inner surface of the thigh. In the control experiments we injected the same volumes of physiological saline as of antigens.

EXPERIMENTAL AND DISCUSSION OF RESULTS

We performed 4 groups of experiments. In the first group (8 experiments) we recorded changes in the action potentials of the nerves in response to intradermal injection of typhoid antigen. The action potentials of the saphenous nerve were distinguished on the records by a background of low amplitude (up to 4-5 μv) waves of frequency over 50 cps, on which waves of a frequency of 6-7 cps and an amplitude of 10-12 μ v could be clearly discerned. The background biopotentials of the auricular nerve consisted of waves of a frequency greater than 50cps, interrupted by sporadic bursts of activity of a frequency of 18-20 cps and an amplitude of 5-6 μv.

In most cases, in response to injection of the typhoid antigen, there appeared a clearly discernable reaction, in the form of waves of a frequency of 5-6 per second, consisting of fast, low-voltage impulses, and of diphasic waves of an amplitude of 10-12 μv, which were replaced by regular rhythmic waves of an amplitude of up to 15 μv and a frequency 14-16 per second, and these in turn gave place to waves of frequency 18-20 per second and amplitude up to 25 μv. It should be noted that these waves appeared in the form of volleys, clearly evident on the oscillograms (Figure 1).

The above oscillogram illustrates the appearance of volleys, which were absent from the initial background record; the reaction was of short duration, since the recording had reverted to its original form 3 minutes after the injection.

The above findings are evidence that injection of antigen causes considerable change in the biopotentials of the nerves studied by us. It hence follows that typhoid antigen gives rise to excitation of skin receptors, recorded as action potential waves in the cutaneous nerves (Figure 1).

In the second group of experiments we investigated the changes in the electrophysiological activity of the same nerves following intradermal injection of paratyphoid B vaccine; this group consisted of 10 experiments. The initial background activity was identical with that described above. The most frequently encountered reaction to the antigen took the form of a continuous impulsation, composed of fast waves of amplitudes of 30-35 μv, which formed a background to volleys of spikes, of a duration of up to 10 seconds, and an amplitude of 90-100 μv (Figure 2).

The reaction did not appear immediately after introduction of antigen in all the experiments. In four cases injection of antigen was followed by a depression of all the rhythms, and this gave place, after 1-1½ minutes, to an activity of the type described above (Figure 3).

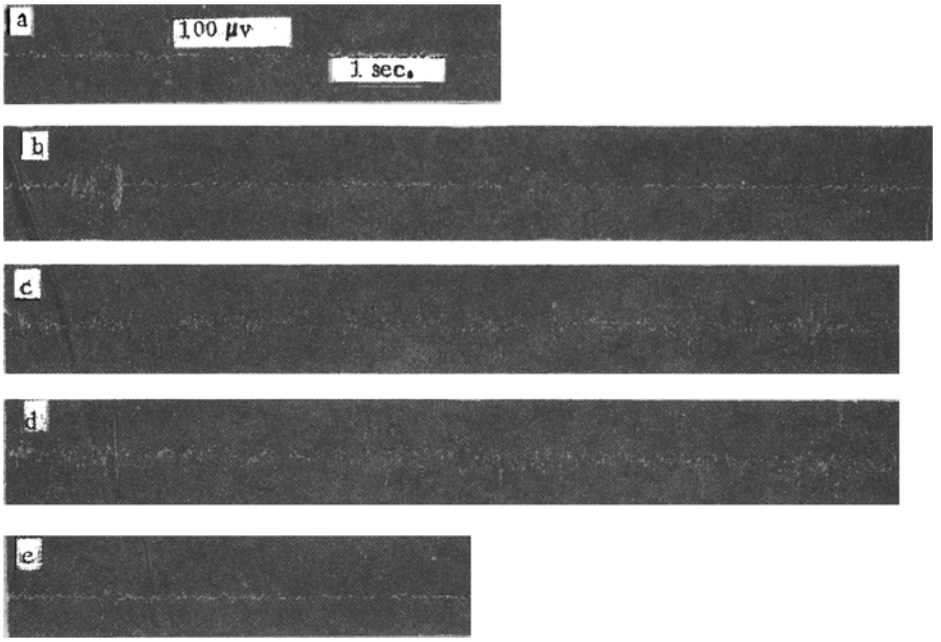

Fig. 1. Changes in bioelectrical activity of the auricular nerve in response to introduction of typhoid vaccine. a) Background; b) immediately after injection of vaccine; c) and d) 1 minute after; e) after three minutes.

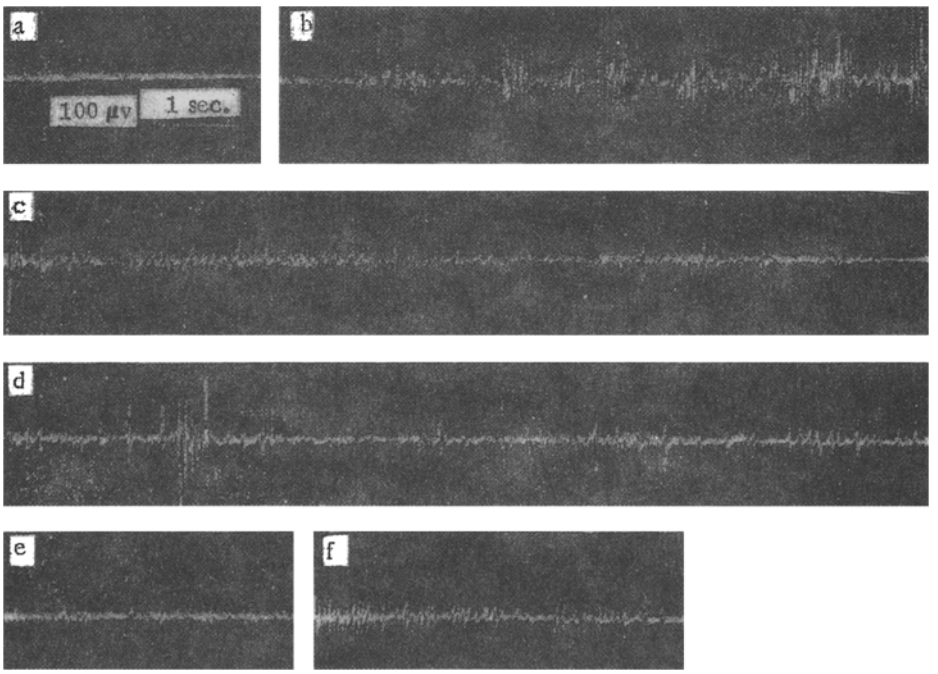

Fig. 2. Changes in bioelectric activity of the saphenous nerve in response to injection of paratyphoid B vaccine. a) Initial background activity; b), c), and d) immediately after injection of antigen; e) after 1 minute; f) after 2 minutes.

It is evident from Figure 3 that a depression of the initial biopotentials took place 20 seconds after injection of paratyphoid B antigen, followed after 1 minute by appearance of waves of a frequency of 15-18 periods per second, and of sporadic spike potentials, which are characteristically an effect of this antigen.

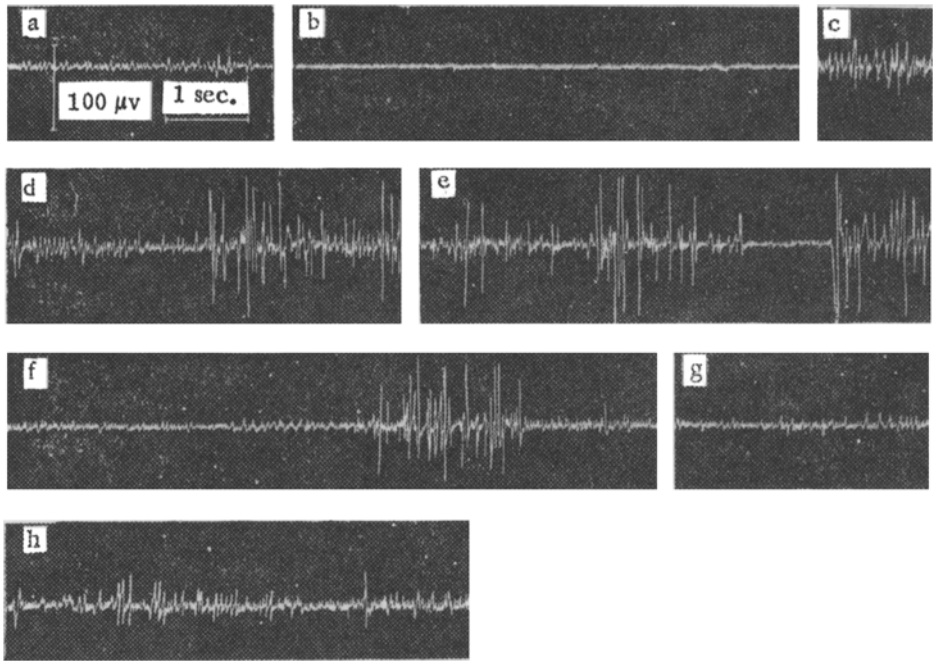

Fig. 3. Changes in bioelectrical activity of the saphenous nerve in response to injection of paratyphoid B vaccine. a) Initial background activity; b) immediately after injection of antigen; c) and d) after 1 minute; e) after 2 minutes; f) after 5 minutes; g) after 7 minutes; h) after 10 minutes.

In the third group of experiments we studied the effect on the biopotentials of the auricular and saphenous nerves of injection of dysentery antigen. Fourteen experiments were performed in this group, from which it appeared that the dysentery antigen is a powerful stimulator of skin receptors (this was expressed in the oscillograms by violent perturbations of the electrical oscillations registered from the nerves). We also found that the dysentery antigen could give rise to two types of reaction. The first type was characterized by appearance of the typical oscillations of biopotential immediately after introduction of the antigen, which, in the second type of reaction, was followed by a depression of electrical activity, lasting up to 1 minute, and then succeeded by Type 1 activity (Figure 4).

It is evident from Figure 4 that injection of dysentery antigen causes a violent reaction, expressed in the pronounced changes in frequency and amplitude of the action potentials of the nerves. In the first variant (Figure 4) the reaction supervened immediately after introduction of the antigen, while in the second variant this effect was preceded by depression of the initial rhythm. The potential waves seen when the reaction had developed were very similar to each other in both cases, which is, in our opinion, of significance. The reaction is characterized by the appearance of single and grouped discharges, of a frequency of 10-15 per second and an amplitude of 10-15 μv. After 1-3 minutes, but sometimes immediately, waves of a frequency of 8-10 per second, and of considerably greater amplitude, made their appearance.

As compared with the preceding groups, the reactions to introduction of dysentery antigen were of greater duration.

It thus appears that introduction of the above antigens results in stimulation of skin receptors, registered in our experiments from the changes in the action potentials of the sensory nerves. It might, however, be argued

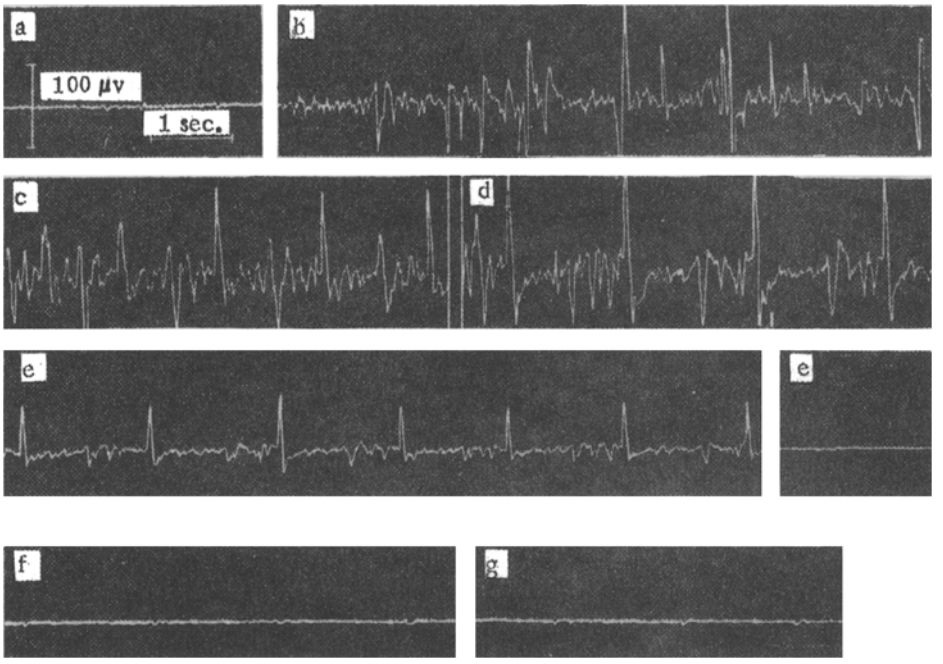

Fig. 4. Changes in bioelectric activity of the auricular nerve in response to injection of dysentery antigen. a) Initial background activity; b) after 20 seconds; c) after 1 minute; d) after 3 minutes; e) after 4 minutes; f) after 5 minutes; g) after 10 minutes.

that the potential changes recorded by us were merely an effect due to mechanical stimulation of the receptors by the prick of the needle or by the fluid introduced. In order to differentiate from such effects we performed 20 control experiments, in which physiological saline was injected, in the same amount as antigen. In these experiments we recorded the biopotentials from the same nerves, before or after injection of antigens. In some cases the saline was injected both before and after injection of antigen. In order to exclude any doubt regarding the possibility of the existence of a prolonged latent period, we performed experiments in which recordings of the electrical activity of the nerves were taken over a period of 15-20, or even 30 minutes after injection of saline. The results obtained showed that injection of physiological saline causes only insignificant changes in the oscillograms, and in some cases there was no change whatsoever in the background rhythm.

The reaction observed after injection of saline was characterized by appearance of fast waves of frequency up to 10 per second, and of fast waves, singly or in volleys, of amplitude 8-10 μv, during 1-2 minutes after injection.