EFFECT OF ADRENALECTOMY AND CORTICOSTEROIDS ON ELECTRICAL ACTIVITY OF THE CAUDAL MESENTERIC SYMPATHETIC GANGLION

A. D. Nozdrachev

UDC 612.893.014.423-06:[612.45-089+615.361.453

Experiments with chronic implantation of electrodes showed that bilateral adrenalectomy lowers the level of spontaneous electrical activity of the caudal mesenteric sympathetic ganglion and lowers the amplitude of electrical responses to acetylcholine, adrenalin, and stimulation of the sciatic nerve. These disturbances are abolished only by administration of hydrocortisone or of hydrocortisone together with desoxycorticosterone. Hydrocortisone increases and desoxycorticosterone inhibits electrical activity of the sympathetic ganglion of dogs with intact adrenals.

* * *

Many workers have shown [1-4, 8, 10-17, 20, 25, 26] that the character of electrical activity of the cortex and subcortical structures undergoes marked changes after adrenalectomy and administration of corticosteroid hormones, which are associated with disturbance of the excitability of these structures. Under these conditions changes have also been found to occur in peripheral nerves [9, 18, 19, 21-24].

So far relatively little attention has been paid to the study of the activity of lower autonomic centers (the caudal mesenteric sympathetic ganglion, CMSG) in experimental adrenal hypo- and hyperfunction, and the present investigation was carried out for this purpose.

EXPERIMENTAL METHOD

Chronic experiments were performed on 6 male dogs weighing about 20 kg, three of which were adrenalectomized. Electrodes were implanted into the CMSG by the method described earlier [7]. By means of an amplitude selector [5], the incoming flow of impulses could be recorded and, at the same time, the impulses could be separated by amplitude and their frequency estimated. Studies were made of spontaneous electrical activity and the electrical responses to intravenous injection of 50 μg acetylcholine, subcutaneous injection of 0.1 mg adrenalin, and nociceptive stimulation of the cutaneous branch of the sciatic nerve. The following three hormonal preparations were used: hydrocortisone (HC) in doses of 10, 50, and 125 mg, desoxycorticosterone acetate (DOCA) of Soviet manufacture, and long-acting adrenocorticotropic hormone (ex-ACTH-in, "Richter") in a dose of 10 i.u. Each hormone was administered to adrenalectomized animals and dogs with intact adrenals for five days, which was followed by an interval of three days, and then another hormone or combination of hormones was given. Dogs received no hormones for 4-5 days after adrenalectomy.

EXPERIMENTAL RESULTS

The electrical activity of the CMSG under chronic conditions consists of constant discharges of biphasic type: low-voltage with an amplitude of 10-12 μV and high-voltage with an amplitude of 12 μV or higher, grouped in the rhythm of the pulse and respiratory movements [6]. Impulses in an irregular rhythm are also found.

In animals with intact adrenals, the maximal increase in number of low-voltage oscillations 3 min after injection of acetylcholine was 154%, and of high-voltage 163%. Nociceptive stimulation of the cutaneous branch of the sciatic nerve was accompanied by an increase in the number of impulses in the low-voltage flow to 162%, and in the high-voltage to 134%. The response to adrenalin was a decrease in the number of impulses in the low-voltage flow to 82% and in the high-voltage to 64% (Fig. 1).

Laboratory of Experimental Endocrinology, I. P. Pavlov Institute of Physiology, Academy of Sciences of the USSR, Leningrad (Presented by Academician V. N. Chernigovskii). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 65, No. 4, pp. 35-39, April, 1968. Original article submitted March 25, 1966.

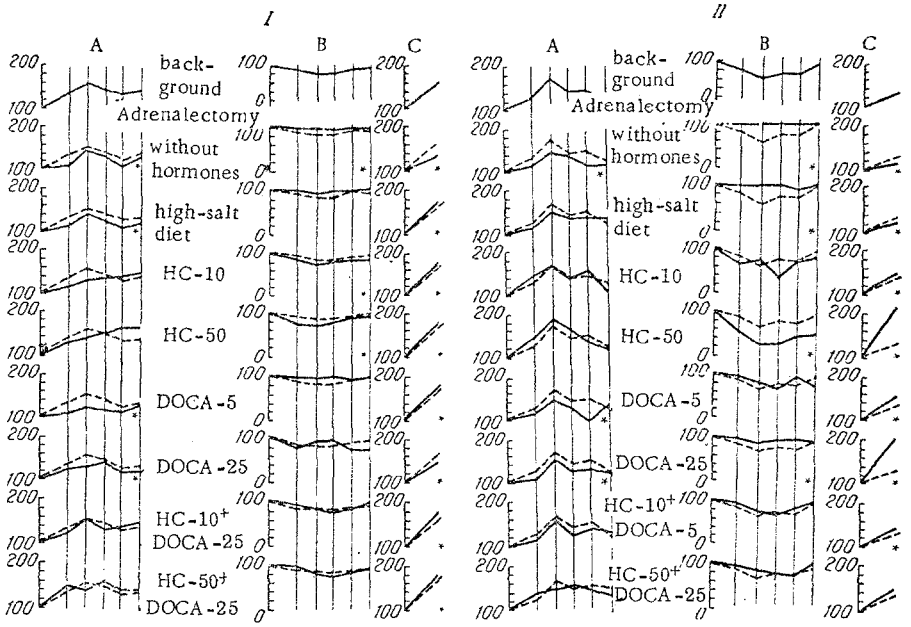

Fig. 1. Comparison of changes in low-voltage (I) and high-voltage (II) flows of impulses in CMSG in response to injection of acetylcholine (A), adrenalin (B), and nociceptive stimulation of sciatic nerve (C). Ordinate of each graph: intensity of impulse activity (in percent of initial level); abscissa: time (in min) after application of stimulus. On each graph except the topmost, a broken line denotes changes during background period. Legend between left and middle columns of graphs gives conditions under which responses were studied. Significance of difference between observed responses and background level denoted by asterisk.

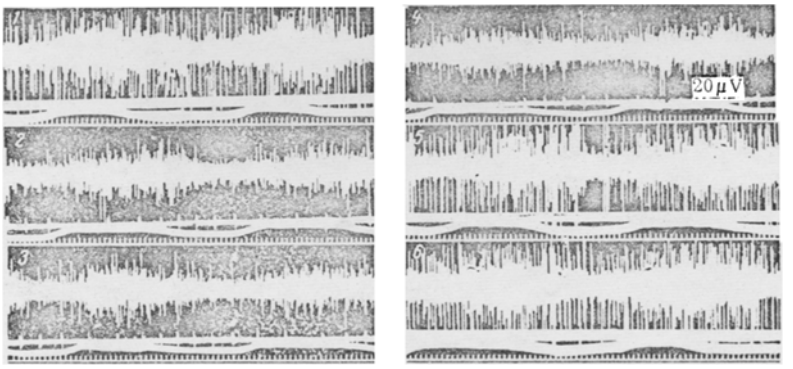

Fig. 2. Spontaneous electrical activity of CMSG of an intact dog (1), after adrenalectomy (2), after administration of a high-salt diet (3), and after administration of 25 mg DOCA (4), 50 mg hydrocortisone (5) and 50 mg hydrocortisone + 25 mg DOCA (6). Order of traces: gangliogram, ECG, pneumogram, time marker (10 cps).

After adrenalectomy and recovery of the animals from the postoperative period, significant changes were found in the responses to these same stimuli. The number of low-voltage impulses in response to acetylcholine was reduced by 10-25% of the background level ($P < 0.05$). The number of oscillations in response to nociceptive stimulation of the sciatic nerve likewise was reduced. The responses to adrenalin were less marked in this case. In the low-voltage flow of impulses they amounted to only 91-95%, but adrenalin produced no changes in the high-voltage flow.

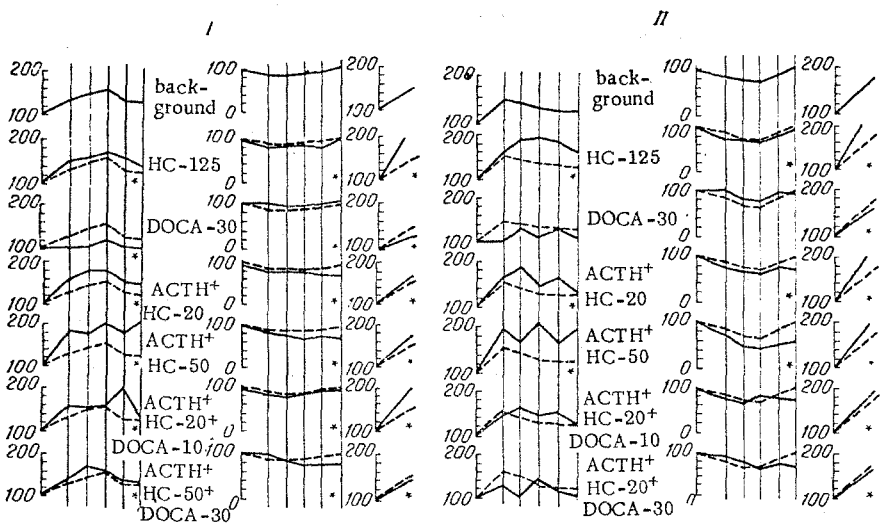

Fig. 3. Comparison of changes in low-voltage (I) and high-voltage (II) flows of impulses in CMSG after administration of corticosteroid hormones to animals with intact adrenals. Remainder of legend as in Fig. 1.

Keeping the animals on a high-salt diet gave slightly higher responses to acetylcholine in both flows of impulses than were observed after adrenalectomy, although they did not reach the background levels. The responses to adrenalin, however, continued to be negligible.

Administration of HC to adrenalectomized dogs modified the amplitude of the recorded electrical responses. Changes in the low-voltage flow during the first 5 min in response to acetylcholine injection were below the background level, but subsequently rose above it. The response of the high-voltage flow returned to the background level. During nociceptive stimulation, an increase in the number of both types of oscillations was observed. Complete recovery to the background level was characteristic of the responses to adrenalin, and after administration of 50 mg HC the changes in the high-voltage flow actually exceeded the original level (Fig. 1).

Administration of DOCA to adrenalectomized animals was not accompanied by an increase in the responses to acetylcholine. However, during nociceptive stimulation the number of high-voltage and low-voltage (with small doses of DOCA) impulses exceeded the initial levels. So far as the responses to adrenalin are concerned, under these conditions they did not differ significantly from the background (Fig. 1).

When both hormones (HC and DOCA) were administered together, the magnitude of the electrical responses to these function tests was the same as before adrenalectomy. A very slight increase in the number of impulses (by 3-14%) was observed only during nociceptive stimulation of the sciatic nerve.

After adrenalectomy the general level of spontaneous electrical activity of the CMSG was appreciably lowered, and administration of a high-salt diet and of DOCA did not significantly modify the character of the neurograms. Restoration of impulse activity was observed only when HC or a combination of HC with DOCA was given (Fig. 2).

In adrenalectomized animals, the magnitude of electrical responses to function tests is therefore depressed. The responses are increased to some degree by keeping the dogs on a high-salt diet or by administration of DOCA. The greatest increase in the responses was observed after administration of HC. Complete restoration of the responses resulted from simultaneous administration of HC and DOCA.

Injection of HC into animals with intact adrenals produced a clear increase in the number of oscillations in response to the acetylcholine test. This increase was particularly marked in the high-voltage flow of impulses. The number of oscillations in response to nociceptive stimulation also increased. The responses to injection of adrenalin likewise were more marked than in the background experiments (Fig. 3).

Following simultaneous administration of HC and ACTH, the responses to acetylcholine showed an increase in the number of oscillations in the low-voltage flow, by comparison not only with the background

period, but also with that observed after administration of HC alone ($P < 0.05$). The responses to the adrenalin test also were more marked.

DOCA, on the other hand, clearly inhibited the responses to all stimuli used ($P < 0.05$). It had a rather stronger action on the low-voltage flow of oscillations.

To analyze the changes in electrical activity following combined administration of all three hormones, two groups of experiments were carried out with different doses of HC and DOCA. Under these conditions no significant differences were found between the effects of small and large doses of the drugs; nor were the changes different from the background indices. This was true of the acetylcholine and adrenalin tests. The situation was rather different during nociceptive stimulation of the sciatic nerve. Small doses of the hormones increased the number of oscillations in both flows, large doses inhibited them. Although these changes differed from those observed in the background experiments by only 4-50%, they were statistically significant.

Just as in adrenalectomized animals, in dogs with intact adrenals the level of spontaneous electrical activity rose after administration of HC alone or in combination with ACTH, and fell under the influence of DOCA. When all three hormones were given together, no changes were observed.

Administration of HC and of HC together with ACTH to animals with intact adrenals was thus accompanied by an increase in the amplitude of electrical responses to stimuli applied. DOCA lowered their amplitude. When all three hormones were given at the same time, the character of the electrical responses was indistinguishable from the background level. Consequently, changes in the electrical indices of the CMSG after adrenalectomy and after administration of corticosteroids are identical with changes observed by investigators in various parts of the brain during adrenal hypo- and hyperfunction.

LITERATURE CITED

1. G. A. Gaidina, In: Electrophysiology of the Nervous System [in Russian], Rostov-on-Don (1963), p. 91.
2. N. A. Emel'yanov and A. N. Panov, Probl. Éndokrinol., No. 6, 108 (1965).
3. V. P. Komissarenko, Probl. Éndokrinol., No. 3, 111 (1963).
4. V. K. Kulagin, Role of the Adrenal Cortex in the Pathogenesis of Trauma and Shock [in Russian], Leningrad (1965).
5. A. D. Nozdrachev and V. L. Fel'cher, Fiziol. Zh. SSSR, No. 11, 1400 (1964).
6. A. D. Nozdrachev, Fiziol. Zh. SSSR, No. 9, 1152 (1966).
7. A. D. Nozdrachev, Byull. Éksp. Biol., No. 3, 15 (1967).
8. K.V. Sedenko, Abstracts of Proceedings of a Scientific Meeting to Review Work of Rostov Medical Institute [in Russian], Rostov-on-Don (1956), p. 474.
9. P. Chauchard, Rev. Sci. (Paris), 90, 120 (1952).
10. M. R. Covian, M. C. Lico, and J. Antunes-Rodriges, Arch. Int. Pharmacodyn., 146, 81 (1963).
11. J. M. Delgado, Electroenceph. Clin. Neurophysiol., 10, 365 (1958).
12. F. Faure, Rev. Neurol., 100, 255 (1959).
13. S. Feldman, J. Todt, and R. W. Porter, Neurology (Minneap.), 11, 109 (1961).
14. S. Feldman, Arch. Neurol. (Chic.), 7, 460 (1962).
15. W. J. Friedlander and E. Rottger, Electroenceph. Clin. Neurophysiol., 3, 311 (1951).
16. G. H. Glaser, Arch. Neurol. Psychiat., 73, 38 (1955).
17. A. Herz, H. Krupp, and M. Monnier, Pflüg. Arch. Ges. Physiol., 272, 442 (1961).
18. R. Lecoq, P. Chauchard, and H. Mazonen, Bull. Soc. Chim. Biol. (Paris), 34, 239 (1952).
19. R. Lecoq, Rev. Path. Comp., 54, 529 (1954).
20. I. Pine, F. L. Engerl, and T. B. Schwartz, Electroenceph. Clin. Neurophysiol., 3, 301 (1951).
21. E. R. Ramey and M. S. Goldstein, Physiol. Rev., 37, 155 (1957).
22. A. Slocombe, H. Hoagland, and J. Praglin, Fed. Proc., 11, 149 (1952).
23. A. Slocombe, L. Tozian, and H. Hoagland, Am. J. Physiol., 179, 89 (1954).
24. D. M. Woodbery, Recent Progr. Hormone Res., 10, 65 (1954).
25. D. M. Woodbery, P. Timiars, and A. Vernadakis, In: Hormones, Brain Function and Behavior, New York (1957), p. 27.
26. D. M. Woodbery, Pharmacol. Rev., 10, 275 (1958).