ACTION OF PRODUCTS OF INTERMEDIATE METABOLISM ON THE CHARACTER OF THE AFFERENT IMPULSES IN THE AORTIC NERVE OF THE CAT

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The work of Diamond and Howe [3] and of Gernandt [4] has demonstrated a disturbance in the flow of impulses in the aortic nerve in response to changes in the composition of the blood gases and to administration of a product on intermediate metabolism — acetic acid. No information concerning the effect of other products of intermediate metabolism on the flow of impulses in the aortic nerve could be found in the literature.

However, because in many pathological states and, in particular, in diseases of the heart, various products of intermediate metabolism may enter the blood stream, it is interesting to study the character of their action on the flow of afferent impulses in the aortic nerve.

The object of the present investigation was to study the action of lactate, acetate, adenylate (AD), adenosinediphosphate (ADP), adenosinetriphosphate (ATP), adrenalin, and noradenalin on the flow of impulses in the aortic nerve.

EXPERIMENTAL METHOD

Experiments were carried out on 23 cats anesthetized with urethane (600 mg/kg) and chloralose (40 mg/kg). After the chest had been opened the animals were transferred to artificial respiration. The left or right aortic nerve was isolated in the thorax and divided above the point of application of the electrodes. To prevent the nerve from drying, it and the electrodes were flooded with warm mineral oil. The afferent impulses were recorded in step with the arterial pressure and EGG (standard lead II) on a Mingograph 42B ("Elema," Sweden) flow-recording four-channel electrocardiograph. For preamplification of the biopotentials, the amplifiers of a type UB 203B cathode-ray oscillograph (Japan) were used.

For recording the neurogram, the following modifications were introduced into the amplifier circuits of the two channels of the Mingograph. The output of the preamplifier of the oscillograph was joined by a coaxial cable through 0.01 μF capacitors to the amplifier cascades of the Mingograph. The auxiliary generator (f = 2 kc) used for thickening the line traced during recording the EGG was disconnected by breaking the folded joint of the resistor R 61 (see the theoretical circuit of the Mingograph). By changing the resistor R 47, the control grids of the tubes V5 and V6 were set at zero by the cathode voltmeter.

The substances for testing were injected into one of the pulmonary veins. By means of a catheter introduced through the vein, the substances entered the left atrium directly, thus facilitating their action on the aortic receptors in high concentration.

Lactate 2-10% was given in a dose of 0.2-0.5-0.8 ml, acetate 1-2-10% in a dose of 0.4-0.8 ml, AD 0.1% in a dose of 0.8 ml, ADP 0.1% in a dose of 0.8 ml, ATP 0.1% in a dose of 0.5-0.8 ml, adrenalin 0.005-0.01% in a dose of 0.4-0.8 ml, and noradrenalin 0.01% in a dose of 0.4 ml.

EXPERIMENTAL RESULTS

In normal conditions discharges of impulses 50-150 μV in amplitude and 80-190 msec (mean 120 msec, Fig. 1) in duration, were detected in the aortic nerve. The systolic volley appeared immediately after the QRS complex of the EGG and corresponded to the phase of rapid expulsion of blood on the arterial pressure curve.

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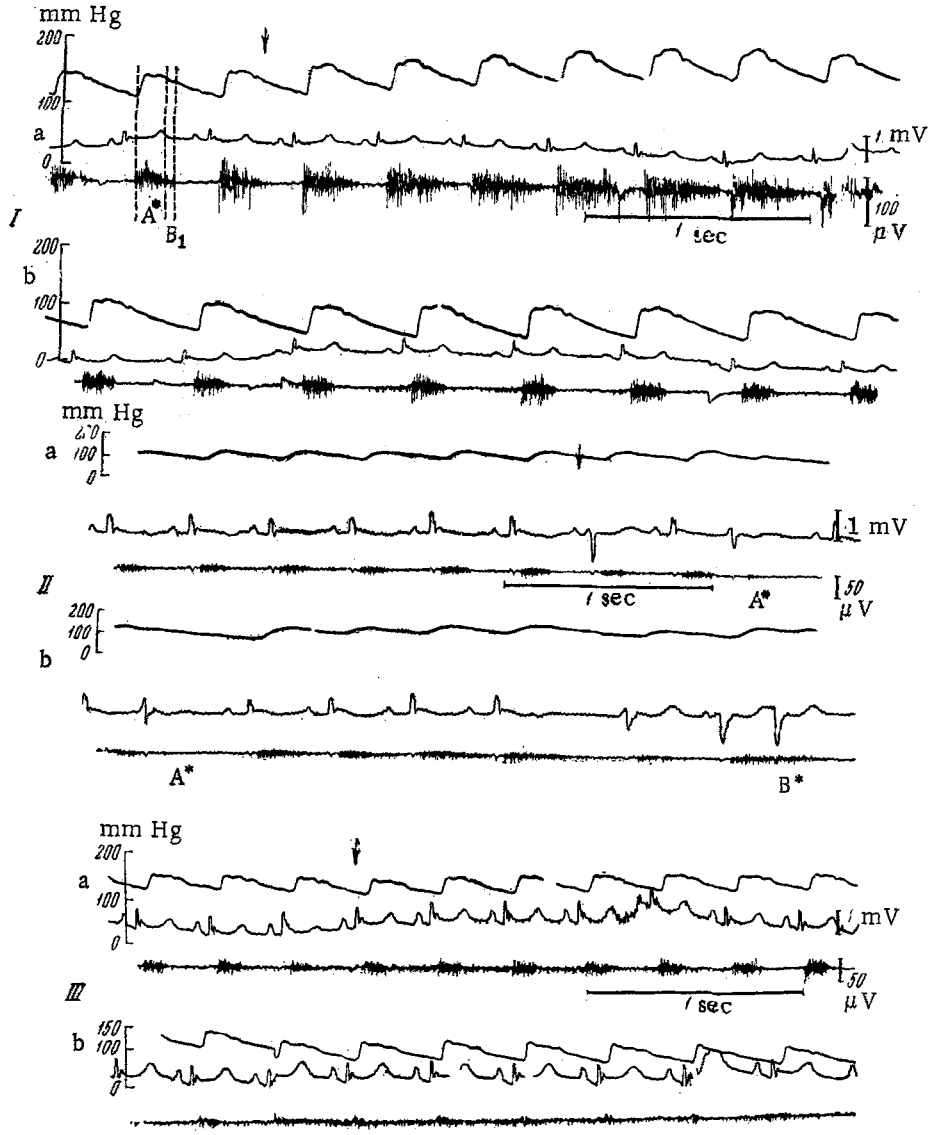

*No explanation of this notation is given in the Russian—Publisher's note.

Fig. 1. Three types of changes in the flow of afferent impulses in the aortic nerve under the influence of the substances tested. From top to bottom: arterial pressure; EGG lead II; neurogram; injection of the substances is shown by an arrow. I — Increase in power and duration of the volley accompanied by an increase in arterial pressure, immediately after injection of adenylate; II — changes in the flow of impulses and arterial pressure 10 sec after injection of adrenalin; III — appearance of low-amplitude impulses, not grouped into a volley, at the time of a decrease of arterial pressure 15 sec after injection of ADP.

After injection of the various substances into the left atrium three types of changes were observed in the flow of impulses in the aortic nerve. The first type of changes was observed after injection of AD, lactate, acetate, lobeline, and ATP and ADP. In these experiments changes in the flow of impulses took place after a very short latent period — 200-500 msec (Fig. 1,I). For a short time (1-6 sec) after injection of the substance the amplitude and duration of the systolic volley were increased, so that now it occupied not only systole but also a large part of diastole. This change in the flow of impulses took place simultaneously with an increase in the arterial pressure (by 20-30 mm Hg) or slightly before it. In the latter case the increase in arterial pressure could be regarded as a reflex response to excitation of the aortic chemoceptors.

The second type of changes in the flow of impulses was observed following injection of adrenalin and noradrenalin. The changes in the flow of impulses in the aortic nerve did not begin to take place until 10-15 sec after the injection. It is clear from Fig. 1, II that after injection of adrenalin the systolic volley became more intensive and

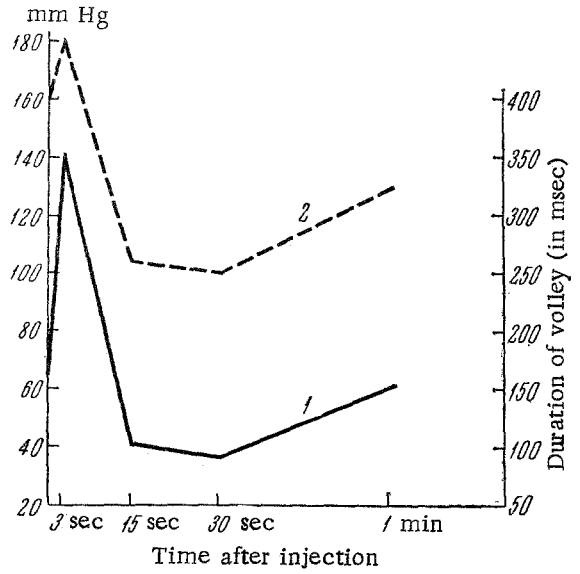

Fig. 2. Changes in the duration of the systolic volley (1) in the aortic nerve and the arterial pressure (2) after injection of adrenalin.

its duration increased parallel with the increase in arterial pressure. During extrasystole, which hardly ever caused an increase in the arterial pressure, the systolic volley was very weak, and during a group of extrasystoles, with a marked increase in arterial pressure, fusion of two volleys in the aortic nerve was observed (see Fig. 1, II).

The results described, and a comparison of the duration of the volley and level of the arterial pressure (Fig. 2) demonstrate the baroceptor character of the impulses observed. Evidently, this flow of impulses corresponded to the activity of the afferent fibers arising from the aortic baroceptors [6].

The reaction to adenylate, lactate, and acetate, and also the lobeline, ATP, and ADP thus begin with a hemoreflex with a very short latent period (up to 200-500 msec), whereas the response to injection of adrenaline and noradrenalin only began to develop after 10-15 sec, and the pattern of its impulses was baroceptor in character.

The first type of reaction was observed in response to the injection of ATP and ADP (Fig. 1, III). Against the background of severe hypotension and bradycardia developing 10-15 sec after the injection, the volleys of impulses were depressed or in some cases disappeared completely, with the appearance of a continuous flow of low-amplitude impulses, increasing in amplitude and frequency toward the end of diastole. In their character these impulses resembled the "slow" impulses discovered by Jarish and Zotterman [5] and by B. S. Kulaev [1] in the depressor nerves following application of nicotine to the heart. Since the activation of this diastolic flow of impulses appeared in every cardiac cycle and was not connected with respiration, it may evidently indicate changes in the metabolism in the heart tissue, and it was evidently chemoceptor in nature. Since the aortic nerves innervate not only the arch of the aorta, but also the heart [2], it is likely that this suggestion is correct. However, because in the present experiments the diastolic flow of impulses did not appear until 10-15 sec after injection, when the concentration of the injected substances had probably begun to diminish, the possibility of another explanation cannot be ruled out. This flow of impulses was perhaps the result of asynchronous activity of the mechanoceptors of the heart or the arch of the aorta, activated by the sharp fall of arterial pressure.

Hence, in response to the injection of products of intermediate metabolism and of physiologically active substances, three main types of changes could be detected in the flow of impulses in the aortic nerve: an increase in the strength and duration of the systolic volley, accompanied by an increase in the aortic pressure (chemoreflex), changes in the baroceptor impulses running parallel to the changes in arterial pressure, with a long latent period, and the appearance of low-amplitude impulses, not grouped into volleys, in association with profound hypotension.

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