ADRENOCEPTOR ACTION OF NEURONS OF THE SUPERIOR CERVICAL AND CAUDAL MESENTERIC SYMPATHETIC GANGLIA IN CATS

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Experiments on the superior cervical and caudal mesenteric sympathetic ganglia of cats showed that dopamine (DA), like noradrenalin (NA) and adrenalin (A), inhibits cholinergic conduction. DA activity in the superior cervical ganglion is 2 and 3 times less respectively than NA and A activity, whereas in the caudal mesenteric ganglion, DA is 50 times more active than NA as regards ability to inhibit cholinergic conduction. The effects of DA and NA in the superior cervical ganglion are abolished by dihydroergotamine, phentolamine, and haloperidol, but not by tropaphen and chloropromazine. In the caudal mesenteric ganglion the inhibitory effect of NA is reduced by phentolamine, dihydroergotamine, and chlorpromazine but not by haloperidol. Conversely, haloperidol and chlorpromazine reduced the inhibitory effect of DA on cholinergic conduction in the caudal mesenteric ganglion, whereas phentolamine, dihydroergotamine, and deseryl were ineffective. It is postulated that the high level of development of the dopaminergic mechanism of inhibition of cholinergic conduction in the caudal mesenteric sympathetic ganglion may lie at the basis of DA-induced dilatation of mesenteric and renal blood vessels and the hypotensive action of DA.

KEY WORDS: adrenergic reception; superior cervical and caudal mesenteric sympathetic ganglia.

Dopamine (DA) lowers the arterial blood pressure in rabbits, guinea pigs [4], and dogs [2] chiefly through dilatation of the mesenteric and renal vessels [2, 8, 12]. In cats, a hypotensive effect of DA is found if its pressor action is inactivated by blocking the vascular α adrenoceptors [3]. It is unlikely that dopamine hypotension is due to direct activation of dopamine receptors of the smooth muscles of the vessels [10], for DA does not lower muscular tone in isolated segments of interlobar arteries of the kidneys or omentum, the abdominal aorta, and the posterior vena cava of dogs [6, 9]. Vasodilatation in the hind limb of dogs induced by DA cannot be produced after removal of the lumbar sympathetic chain [11]. This suggests that the hypotensive action of DA is exerted at the level of the sympathetic ganglia. DA is known to depress conduction in the superior cervical sympathetic ganglion [5]. However, the nature of the DA effect on cholinergic excitation in different sympathetic ganglia has not received special study.

The object of this investigation was to compare the effect of adrenalin (A), noradrenalin (NA), and dopamine (DA) on cholinergic excitation in the superior cervical and caudal mesenteric ganglia of cats and to make a pharmacological analysis of the adrenoceptor properties of the neurons of these ganglia.

EXPERIMENTAL METHOD

Experiments were carried out on 142 cats anesthetized with a mixture of urethane (1 g/kg) and chloralose (0.05 g/kg). The effects of A (hydrochloride), NA (hydrotartrate), and DA (hydrochloride) on the function of the superior cervical ganglion were judged from changes in contractions of the nictitating membrane following injection of amines into the central end of the divided lingual artery. Contraction of the

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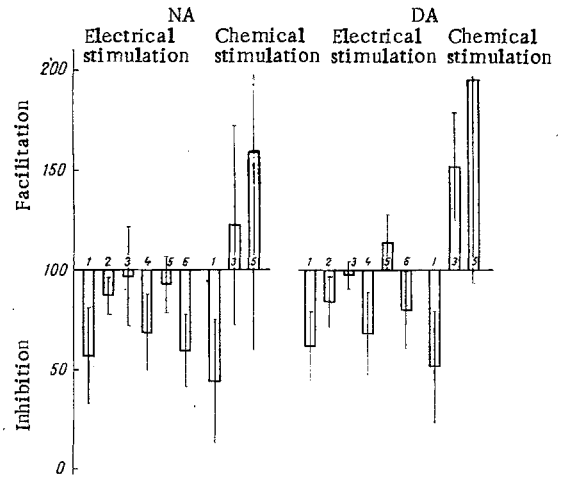

Fig. 1. Effect of NA and DA, injected before and after their antagonists into superior cervical ganglion, on excitation of the ganglion through stimulation of preganglionic nerve or application of acetylcholine to ganglion. Abscissa, effect of 198 μg NA or 214 μg DA (1); the same after dihydroergotamine (2), haloperidol (3), tropaphen (4), phentolamine (5), and chlorpromazine (6) in a dose of 10 μg; ordinate, change in amplitude of contraction of nictitating membrane (in % of control contraction, taken as 100%).

nictitating membrane was induced by stimulation of the preganglionic nerve for 5 sec with square pulses with a frequency of 15 Hz and duration 0.5 msec, and also by injection of acetylcholine (iodide, 50 μg) into the lingual artery in the direction of the ganglion. The effects were recorded 3 and 6 min after injection of the bioamines.

The effect of the amines on cholinergic conduction in the ganglia of the caudal mesenteric plexus was studied on the isolated perfused ganglion [1]. Preganglionic fibers were stimulated with single square pulses (4 V, 1 msec). The action potential (AP) was recorded by platinum electrodes from the postganglionic fibers of the colic nerve and led to the input of a type UBP-1-02 amplifier. The amplified signal was led to a type ÉMOF-2-01 oscilloscope with driven sweep. The ISE-01 pulse generator with radiofrequency output attachment was used as the source of square pulses. Synchronization of stimulation of the preganglionic fiber with triggering the sweep of the oscilloscope and with photography was carried out by means of a "Zenit" camera with synchronized contact. APs were recorded 1.5-2 min after injection of NA or DA in concentrations of 10^{-9}-10^{-4} g/ml into the perfusion system. The solutions of amines flowed through the ganglion for 2-3 min.

To analyze the adrenoceptor properties of the neurons of the sympathetic ganglia, catecholamine antagonists were used: dihydroergotamine, phentolamine, tropaphen, chlorpromazine, haloperidol, and deseryl. The latter were injected into the central end of the divided lingual artery in doses of 10 μg 3 min before injection of the amines, and in the experiments on the isolated ganglion, in concentrations of 10^{-10}-10^{-5} g/ml 5 min before addition of the amines.

EXPERIMENTAL RESULTS AND DISCUSSION

Injection of catecholamines into the lingual artery in a direction toward the superior cervical ganglion reduced the amplitude of contractions of the nictitating membrane induced by preganglionic stimulation. The minimal doses reducing the amplitude of contractions by 5-10% were 10, 20, and 30 μg for A, NA, and DA respectively; doses inhibiting contraction by 50% were 75, 198, and 214 μg respectively. DA activity was thus only half that of NA activity and one-third that of A activity. Inhibition of cholinergic conduction in the superior cervical ganglion was due mainly to the postsynaptic effects of the catecholamines, for A, NA, and DA in doses of 75, 198, and 214 μg reduced the amplitude of contractions of the nictitating membrane by about 50%, regardless of whether cholinergic excitation was caused by preganglionic stimulation or by application of acetylcholine to the ganglion.

As Fig. 1 shows, the inhibitory effect of NA and DA on cholinergic excitation in the superior cervical ganglion was abolished by dihydroergotamine, phentolamine, and haloperidol but not by tropaphen or chlorpromazine.

The amplitude of the AP recorded in the postganglionic fibers during stimulation of the preganglionic nerves by a single pulse decreased during perfusion of the caudal mesenteric ganglion by solutions of NA and DA. The effect depended on the catecholamine concentration (Fig. 2). The minimal inhibitory effect on cholinergic conduction in this ganglion was produced by NA in a concentration of $5 \cdot 10^{-6}$ g/ml and by DA in a concentration of 10^{-7} g/ml, i.e., DA was 50 times more active than NA in its ability to exhibit cholinergic conduction in the caudal mesenteric ganglion of the cat. In a concentration of 10^{-4} g/ml, NA reduced the amplitude of the AP on the average by 28±2%, and DA by 52±14%. The inhibitory effect of NA on cholinergic conduction in the caudal mesenteric ganglion was significantly reduced by preliminary perfusion of the ganglion by solutions containing phentolamine, dihydroergotamine, or chlorpromazine. Haloperidol did not change the inhibitory effect of NA (Fig. 3). Conversely, haloperidol and chlorpromazine reduced the inhibitory effect of DA on cholinergic conduction in the caudal mesenteric ganglion, whereas phentolamine, dihydroergotamine, and deseryl were ineffective.

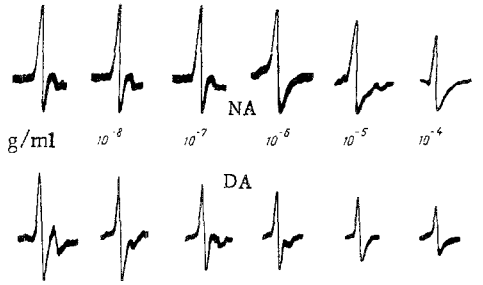

Fig. 2

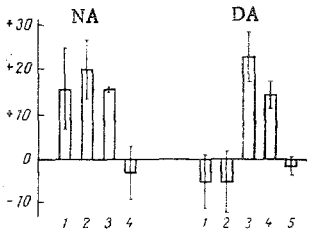

Fig. 3

Fig. 2. Effect of NA and DA on cholinergic conduction in caudal mesenteric ganglion of a cat: change in amplitude of action potentials in postganglionic nerve during stimulation of preganglionic nerves by a single pulse.

Fig. 3. Effect of adrenolytics and deseryl on inhibition of cholinergic conduction due to NA or DA in caudal mesenteric ganglion of a cat. Abscissa, antagonists of bioamines: 1) phentolamine, 2) dihydroergotamine, 3) chlorpromazine, 4) haloperidol, 5) deseryl; ordinate, difference between values of depression of AP amplitude under influence of amine alone and of amine injected after antagonists (in % of initial value of AP).

The results indicate that neurons of the superior cervical and caudal mesenteric sympathetic ganglia differ in their sensitivity to DA: Neurons of the mesenteric ganglion are much more sensitive to DA than to NA, whereas neurons of the superior cervical ganglion, on the other hand, are more sensitive to NA. The dopaminergic mechanism of inhibition of cholinergic excitation of sympathetic neurons, described for the superior cervical ganglion [7], is even more characteristic of neurons of the abdominal sympathetic ganglia. Participation of this mechanism may lie at the basis of the dilatation of the mesenteric and renal vessels induced by DA, and also of its hypotensive action. The essential fact is that the neuroleptics haloperidol and chlorpromazine act as antagonists of DA in the mesenteric ganglion, but not phentolamine and dihydroergotamine, which abolish the effects of DA on neurons of the superior cervical ganglion. This explains why haloperidol and many of the phenothiazine neuroleptics, but not the α adrenoblockers, abolish DA-induced vasodilatation [3, 12].

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