ACTIVITY OF NEURONS OF THE BULBAR PRESSOR STRUCTURES IN REFLEXES FROM THE MECHANOCEPTORS OF THE URINARY BLADDER AND THE AFFERENT FIBERS OF THE TIBIAL NERVE

A. M. Blinova, N. K. Saradzhev, and F. D. Sheikhon

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Several investigations have shown that differential changes take place in the tone of the regional blood vessels [7] and in the electrical activity of the sympathetic nerves innervating the vessels of various organs [3-5, 9] in association with pressor reflexes from different receptor zones. These results have led to the conception of differentiation between integrative processes in the vasomotor center depending on the place of origin and the character of the afferent impulses reaching it. The authors have attempted to eludicate this problem by studying the reactions of individual neurons in various parts of the bulbar pressor structures during certain pressor reflexes. During a carotid pressor reflex, as previously demonstrated [2], the overwhelming majority of neurons react by excitation – by an increase in the frequency of spontaneous discharges – and only in a few neurons is the frequency of the discharge reduced.

In the present investigation the reactions of neurons in the same bulbar pressor structures were studied during pressor reflexes arising from the mechanoceptors of the urinary bladder and from the afferent fibers of the tibial nerve.

EXPERIMENTAL METHOD

The investigation was carried out on 30 cats weighing from 2 to 3 kg, anesthetized with urethane. In 10 experiments, immobilization of the animal was produced by intravenous injection of ditilin (succinylcholine).

The main details of the technique have been described earlier [2]. The action potentials of the neurons were detected by steel needle microelectrodes with a point 2-25 μ in diameter and recorded on a two-channel cathode-ray oscillograph. The reflex from the urinary bladder was evoked by distending it with air under a pressure of 50-70 mm Hg. The afferent fibers of the tibial nerve were stimulated by local heating of the nerve with a special electrothermode, heated by a dc battery (250-500 mA). The temperature of the electrothermode reached 48-50°. According to Von Euler [12] and Dodt [11], local heating of a nerve excites the thin afferent fibers of group C and A, but does not excite the thicker afferent and the efferent fibers. The duration of stimulation was 15-45 sec. Heating was repeated at intervals of 15-20 min. The arterial pressure in the femoral or carotid artery was recorded by a mercury manometer on a kymograph or by an Alvar electromanometer on one of the channels of the cathode-ray oscillograph.

EXPERIMENTAL RESULTS

Neurons with spontaneous activity were found in the region of the bulbar reticular nuclei – lateral, medial, parvicellular and gigantocellular. The following criteria of the vasomotor function of the tested neuron were used: the pressor reaction during stimulation through a microelectrode of the "point" where the neuron was situated; the increase in activity of the neuron during a fall in pressure in the carotid sinus; the increase in activity of the neuron during a rapid mechanical (Fig. 1) lowering of the arterial pressure and the decrease in its activity with an increase in pressure. The arterial pressure was changed by withdrawing blood from the femoral artery (3-5 ml) and by reinjecting it [13].

Hence, the neurons investigated could react during the pressor reaction to depressor impulses from the mechanoceptors of the blood vessels. The results obtained are given in the table.

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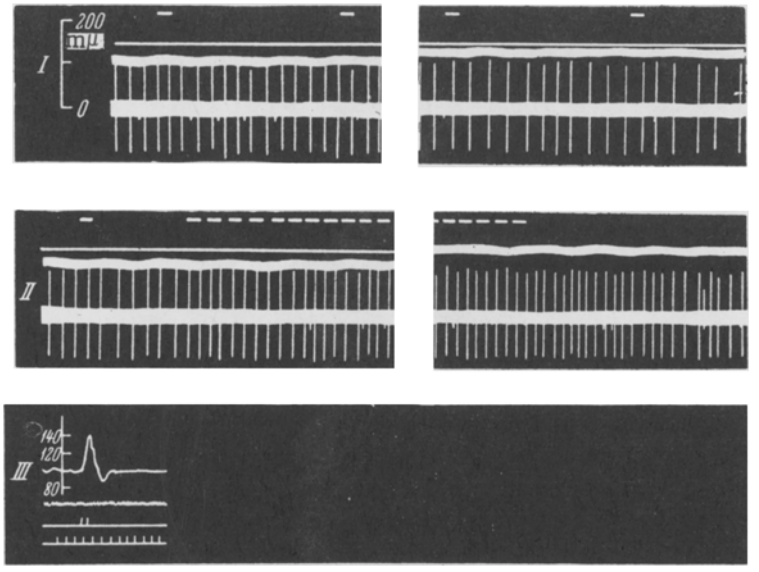

Fig. 1. Reaction of one of the neurons tc stimuli used to determine the vasomotor function of the neurons. Microelectrode (diameter of point, 8 μ) in the parvocellular nucleus. I) Mechanical lowering and raising of arterial pressure: on the left – frequency of discharges during a decrease in pressure, on the right – during an increase; II) decrease in pressure in the carotid sinus: on the left – beginning of compression of carotid artery, on the right – end; III) stimulation of the "point" where the neuron was located. On the oscillogram (from top to bottom): time marker (in sec), period of stimulation is marked by a transfer of the time marker through 0.1 sec; zero line of pressure; arterial pressure; discharges of neuron. On the kymogram (from top to bottom): arterial pressure, respiration, marker of stimulation, time marker (5 sec).

Character of Changes in Discharges of Neurons

	No. of neurons				Total
	++	+–	0–	––	
Pressor reflex:					
from urinary bladder	21	9	6	2	38
from tibial nerve	18	14	9	3	44

Legend: ++) increase in frequency; +-) initial increase in frequency and decrease on raising blood pressure; 0-) slowing of rate with increase of pressure; --) slowing of rate.

As the table shows, the neurons reacted differently in each reflex. The ratio between the neurons reacting differently also varied in the two reflexes. One of the possible factors responsible for the difference between the reactions of the neurons was interference of the afferent impulses from the stimulated zone and from the mechanoceptors of the blood vessels excited by the increase in arterial pressure brought about by stimulation.

Comparison of the time of appearance of the changes in activity of the neurons and the changes in arterial pressure revealed certain special features distinguishing the reaction of the neurons to afferent impulses.

Most neurons reacted during both reflexes by excitation – by an increase in the frequency of the discharges developing 0.5-2 sec after the beginning of stimulation, which may be regarded as the result of the action of afferent impulses from the stimulated zone. In some neurons the increase in frequency of the discharges continued throughout stimulation, despite the increase in arterial pressure (Figs. 2 and 3B, III-V). This shows that the excitation evoked by the afferent impulses was strong and predominated over the depressant action of the impulses from the mechanoceptors of the blood vessels. In other neurons the increase in the frequency of the discharges was transient (3-5 sec), and when the pressure was increased it gave way to a gradual slowing of the discharges (Fig. 3A, II and III). In these neurons excitation was less strong and could be depressed by impulses from the vascular mechanoceptors. In some neurons no initial change in the frequency of the discharges was observed, but as the arterial pressure increased, a decrease in the frequency of the impulses developed (Fig. 3B, I and II). The afferent impulses from the stimulated zones did not affect these neurons, and they showed only the depressant effect of impulses from

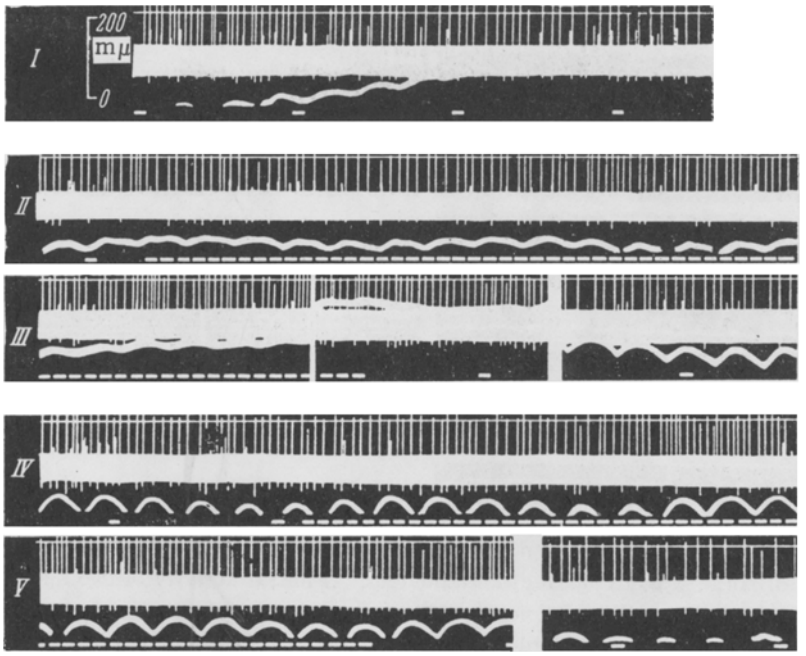

Fig. 2. Neuron reacting by an increase in frequency of discharges during two reflexes. Microelectrode (diameter of point, 15 μ) in lateral nucleus. I) Test with mechanical decrease and increase of arterial pressure; II) beginning of stimulation of tibial nerve (beginning of increase in frequency of discharges 2.3 sec later); III) on the left – 12 sec later, in the middle – time of discontinuing stimulation, on the right – 6 sec after end of stimulation; IV) beginning of distention of urinary bladder (increase in frequency of discharges begins 1.5 sec later); V) on the left, end of distention, on the right – 1 min after end of distention. On the oscillogram (from top to bottom): discharges of neuron, arterial pressure (upward deflection of the beam corresponds to an increase in pressure), time marker, per second; period of stimulation denoted by a transfer of the time marker through 0.1 sec.

the vascular mechanoceptors. The afferent impulses from the stimulated zones could also cause depression of the activity of the neurons. For instance, in some neurons, a slowing of the discharges was observed a fraction of a second after the beginning of stimulation and continuing throughout the period of stimulation until the pressure increased (Fig. 3A, IV and V). A similar depressant action of different afferent impulses on the reticular neurons of the brain stem has been observed by several investigators [6-8, 10, 14].

Hence, impulses of one afferent system have no effect on some vasomotor neurons, while in others they evoke a differing degree of excitation (in some stronger, in others weaker), and in certain neurons they depress the spontaneous activity. Hence it follows that different neurons of the bulbar pressor structures possess distinctive functional properties. These may be attributed to differences both in the synaptic connections of the neurons with the afferent systems and in the excitability of the different neurons in relation to incoming impulses. The unequal excitability of different bulbar pressor elements in connection with different parameters of stimulating current has been demonstrated previously by the authors [1].

Comparison of the reactions of the same neuron to stimulation of the mechanoceptors of the urinary bladder and of the afferent fibers of the tibial nerve shows that the vasomotor neurons can react to impulses in two afferent systems, and this reaction may be in the same or in different directions. It is clear from Fig. 1 that the neuron responded by excitation during both reflexes. In Fig. 3A the discharge of two neurons of different amplitude can be seen. The neuron with discharges of high amplitude responded by excitation to stimulation of the nerve and by depression to distention of the urinary bladder. Meanwhile, other vasomotor neurons react to impulses of only one afferent system. It is clear from Fig. 3B that the neuron did not respond to impulses from the mechanoceptors of the urinary bladder, but reacted by excitation to impulses from the tibial nerve. Neurons showing different reaction were found in all the structures investigated and sometimes were situated closer together (see Fig. 3A).

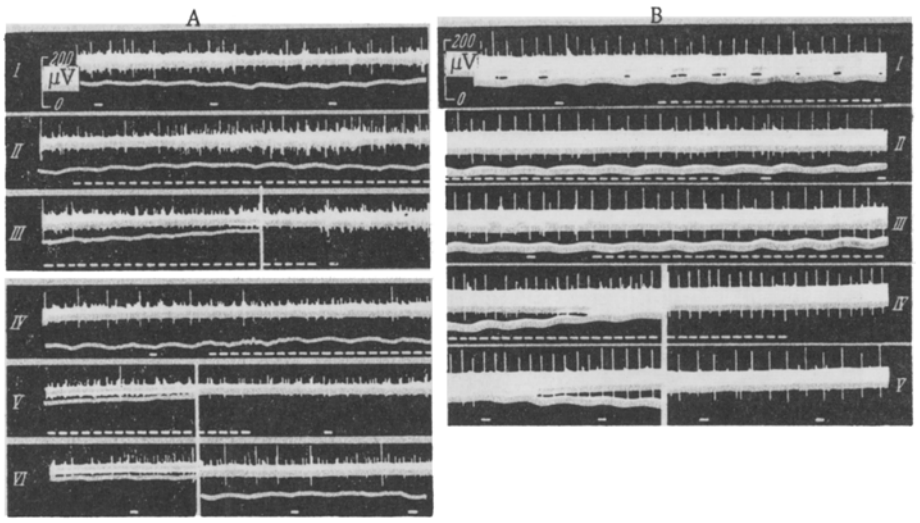

Fig. 3. Divergent reactions of neurons during two reflexes. A) Microelectrode (diameter of point, 8 μ) in parvicellular nucleus. I) Initial activity of two neurons; II) beginning of stimulation of nerve; III) on the left – 10 sec later, on the right – end of stimulation (beam recording pressure merged with noise); IV) beginning of distention of urinary bladder; V) on the left – 11 sec later, on the right – end of distention of urinary bladder (beam recording pressure merged with noise); VI) on the left, 5 sec after end of distention, on the right – restoration of original activity 40 sec later. B) Microelectrode (diameter of point, 12 μ) in lateral nucleus. I) Beginning of distention of urinary bladder; II) end of distention of urinary bladder; III) beginning of stimulation of nerve; IV) on the left – 11 sec later, on the right – 17 sec later (end of stimulation, beam recording pressure merged with noise of oscillograph); V) on the left – 8 sec later, on the right – 1 min after end of stimulation. I and II) downward deflection of the beam of pressure corresponds to an increase in pressure; meanings of remaining tracings the same as in Fig. 2.

It may be concluded from the analysis of these results that when afferent impulses reach the vasomotor center from any receptors, a functional system of neurons, characteristic of that particular source of afferent impulses, and varying in its degree of excitation and inhibition, is formed in the bulbar pressor structures. This may lead to the unequal peripheral effects observed in different pressor reflexes.

SUMMARY

Experiments were carried out on cats under urethane anesthesia. The action potentials of neurons of various bulbar pressor structures were taken off extracellularly by means of microelectrodes (d~ 2 to 25 mc). The vasomotor function of the neuron was judged according to: 1) the pressor reaction to stimulation of the "point" where the neuron was located; 2) the reflex charge in the frequency of neuron discharges during reduction of pressure in the carotid sinus or during rapid mechanical elevation and decrease of the general arterial pressure. It has been found that: 1) different neurons show dissimilar changes of the impulse activity in reflexes both from the urinary bladder mechanoceptors and from the afferent fibers of the tibial nerve. The afferent impulses from one and the same source produced no influence on certain neurons, while in others they caused excitation of a variable degree, and in some neurons, an inhibition of the activity; 2) some neurons respond to afferent impulses both in distention of the urinary bladder and in stimulation of the tibial nerve; 3) neurons reacting in one and different directions are not delimited anatomically. It is concluded that during arrival at the VMC of afferent impulses from some receptors in the bulbar pressor structures a functional system of neurons is formed there, characteristic of a given afferentation, which are distinguished by a variable degree of stimulation and inhibition.

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