NONSPECIFIC MODULATION OF SIGNAL CONDUCTION IN THE CAT VENTROBASAL THALAMUS

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The nucleus ventralis posterolateralis (VPL) and centrum medianum (CM) of the thalamus, on the basis of morphological and physiological characteristics, are included in different nuclear groups of the thalamus, although both nuclei play an important role in the perception and regulation of nociceptive sensation. In this respect CM plays the dominant role, for its bulbar and mesencephalic relays are connected with spinoreticular fiber systems [5, 6]. Projections of tactile-pressor fibers from nuclei of the dorsal column and spino-cervico-thalamic tract are mainly represented in VPL, and also, to some extent, fibers of spinothalamic systems [3, 4].

Electrolytic destruction of CM abolishes the avoidance reaction in cats to nociceptive and other stimuli dangerous for the animal [11]. By coagulation of different parts of VPL or CM it is possible to abolish localized intolerable pain in man [1, 2]. It is also known that when pain perception is suppressed tactile sensation may be preserved [10].

In this connection it was interesting to study functional relations between two subcortical formations, one of which belonged to the specific projection system, the other to the thalamic reticular formation. Accordingly an attempt was made to determine in single cells the role of the nonspecific thalamus in the conduction of signals through the somatosensory relay nucleus.

EXPERIMENTAL METHOD

Acute experiments were carried out on adult cats weighing 3-3.5 kg, immobilized with listenon and artificially ventilated. Weak anesthesia was induced by intraperitoneal injection of pentobarbital (20 mg/kg). In all the experiments the arterial blood pressure was monitored by means of a mercury manometer connected to the femoral artery. Soft tissues were dissected under local anesthesia with 0.5% procaine. Evoked activity of single neurons in VPL was recorded extracellularly by glass microelectrodes with a tip 1-2 μ in diameter, filled with 3 M KCl. Stimulation of the contralateral brachial plexus relative to the relay nucleus was carried out with single square pulses 0.3 msec in duration and with an amplitude of 15-30 V. CM of the thalamus ipsilateral with respect to VPL was stimulated through a coaxial bipolar electrode 400 μ in diameter with single pulses or series of 4 or 5 pulses with a frequency of 200-250 Hz in the series. The duration of a single pulse was 0.5 msec and its maximal amplitude 20 V. The electrodes were introduced into the specified nuclei in accordance with coordinates from the atlas [7]. Unit responses were photographed from the "Disa-Electronic" oscilloscope screen. At the end of the experiment the animal's brain was fixed in 10% formalin and the location of the electrodes determined in frozen sections.

EXPERIMENTAL RESULTS

In 14 experiments 83 neurons in VPL were recorded. Evoked responses of all neurons to stimulation of the brachial plexus were studied during conditioning stimulation of CM thalami. The latent periods of the neurons to peripheral stimulation were distributed over the range from 5 to 18 msec. In this range 65 neurons had a latent period of between 5 and 7 msec (short-latency), and the remaining 18 neurons, a latent period of between 8 and 18 msec (long-latency).

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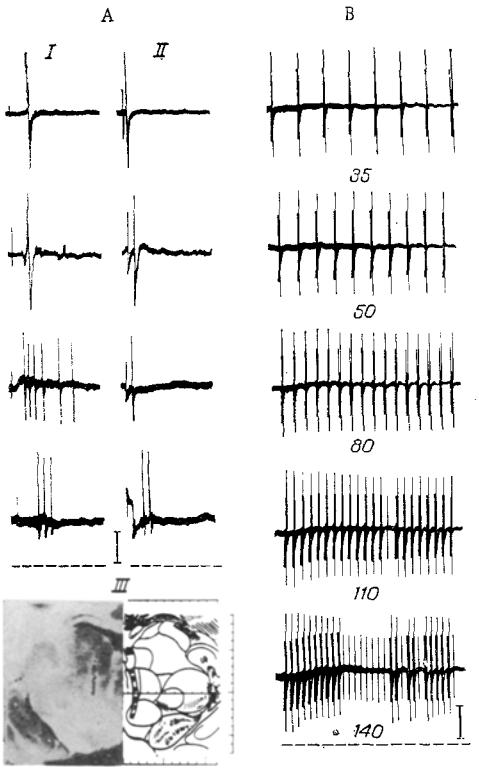

Fig. 1. Responses of VPL neurons to stimulation of contralateral forelimb and CM thalami. A) Evoked responses of four convergent neurons to single stimulation of forelimb (I) and of CM (II), histological verification of position of electrode in CM (III); B) responses of neuron in VPL to repetitive stimulation of CM. Numbers indicate frequency (in Hz). Calibration: 1 mV, 5 msec (A) and 20 msec (B).

In the group of short-latency neurons, besides responses to stimulation of the forelimb, responses to stimulation of CM also were recorded in 11 cells. Responses of four neurons to stimulation of the forelimb (I) and CM thalami (II) are illustrated in Fig. 1A. The latent period of responses to thalamic stimulation was 2-8 msec. This is evidence that connections between the nuclei are predominantly polysynaptic. However, during repetitive stimulation of CM a neuron with latent period of 2 msec followed a frequency of stimulation up to 110 Hz (Fig. 1B). Since the distance between the nuclei is only a few millimeters, it can be concluded that this neuron was activated by not more than 1 or 2 synaptic relays.

Investigation of interaction between signals on convergent neurons was carried out by the use of paired stimuli separated by different intervals. In 8 of 11 neurons changes in the testing response to stimulation of the limb were not observed (Fig. 2A). In the other three neurons the testing response was inhibited within the range from 30 to 100 msec. If the interval between stimuli was reduced, there was a successive increase in the latent period and decrease in the number of spikes until they were totally suppressed, but in the interval from 20 to 50 msec after conditioning stimulation spike activity could be partially restored, with a considerable increase in the latent period (Fig. 2B).

Analysis of neurons whose responses were recorded only from peripheral nerves was carried out by the use of conditioning stimulation of CM by a series of 4 or 5 pulses. Under these conditions a clear inhibitory effect was seen in 23 of 72 neurons. This group included all the long-latency (18 cells) and only 5 short-latency neurons. The testing response to stimulation of the forelimb was inhibited within the range from 20 to 180 msec. Just as in the previous group of neurons, inhibition was expressed as an increase in latent period and a decrease in the number of spikes in the response (Fig. 3A). In short and long intervals (20-40

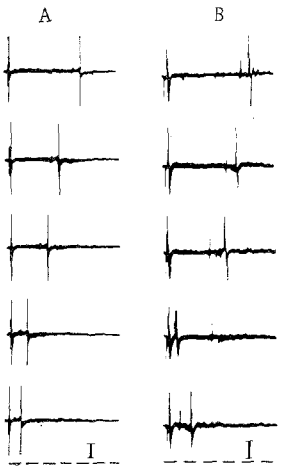

Fig. 2

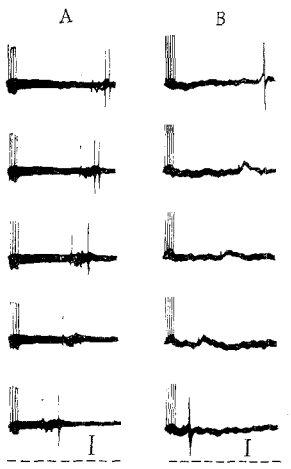

Fig. 3

Fig. 2. Effect of conditioning stimulation of CM on testing responses from forelimb of convergent VPL neurons. A) No change in testing response of short-latency neuron; B) inhibition of testing response in long-latency neuron. Calibration in A and B: 1 mV, 20 msec.

Fig. 3. Character of change in response from forelimb in long-latency VPL neuron during conditioning stimulation of CM by series of pulses. A) Weak suppression of unit activity; B) prolonged inhibition of spike activity of testing response. Calibration in A and B: 1 mV, 20 msec.

and 120-180 msec, respectively) the inhibitory effect was weak, but it developed maximally with average values of the interval between stimuli (50-100 msec). However, the modulating influence of the nonspecific thalamus was more marked on long-latency neurons, in which the period of complete suppression of the testing response could amount to 100 msec (Fig. 3B).

The results are evidence primarily of disparity in the effect of stimulation of CM on VPL neurons. Projections from the medial thalamus activated 11 cells (13.2%). However, this facilitatory effect was hardly associated with any subsequent change in membrane potential and the development of a period of inhibition characteristic of VPL neurons during lemniscal stimulation [9]. Only in 3 neurons of this group was the testing response to peripheral stimulation modified.

An inhibitory effect was found on 26 neurons (31.3%). Of these, 18 were long-latency, the remaining 8 short-latency. As the results of the investigation show, inhibition was exhibited on all long-latency and only on 12.3% of short-latency neurons. In the first case it was more clearly defined and longer in duration.

The differences revealed between the two groups of neurons agree with results obtained by intercellular investigations of VPL during low-frequency stimulation of the medial thalamus [8]. Under these circumstances, the membrane potential of the relay neurons was increased by a few millivolts, but this rarely blocked the cell discharges. In nonrelay neurons, a considerable IPSP developed, against the background of which the EPSP of lemniscal origin did not reach the level of spike activity. On the other hand, functional blocking of CM by the bilateral cooling method showed that the short-latency evoked potential in VPL also remained unchanged [12].

These results and data in the literature are evidence that there are at least two types of neurons in VPL, with different functional connections with the nonspecific thalamus. Besides relay thalamocortical neurons, the nucleus is known also to contain interneurons of the Golgi II type and of the Golgi I reticular type [15]. Racemose endings of lemniscal afferents on relay neurons of VPL ensure highly reliable synaptic relations, so that evoked EPSPs can develop unchanged even during intracellular hyperpolarization [8]. This system of neurons is least exposed to various modulating influences and is intended for rapid connection of receptors with the projection cortex.

Nonlemniscal afferents and collaterals of relay cells approach interneurons with thin terminals and can only change or modulate the activity of these cells [13]. Interneurons have no dominant afferent input, and by

their wide convergent properties they closely resemble neurons of the reticular type. For instance, in Burdach's nucleus – one of the relays to VPL – interaction between signals from the sensomotor cortex, nonspecific nuclei of the thalamus, cerebellum, and brain-stem reticular formation takes place on interneurons by means of which presynaptic inhibition of primary afferents is effected [14].

The thalamic relay nucleus carries out integration at a high level. Thus there is every reason to regard this nonspecific component as an intranuclear system which can determine the degree of tactile and pain perception and can regulate the modal spectrum of the sensory inflow to the cerebral cortex.

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CHANGES IN EFFERENT ACTIVITY IN THE RENAL AND SPLENIC NERVES DURING STIMULATION OF BULBAR RETICULAR NUCLEI

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KEY WORDS: paramedian and ventral reticular nuclei; acetylcholine; renal and splenic nerves.

The role of the medulla in the control of activity of the circulatory system is not in dispute. However, the problem of the functions of its various structures in this process is not yet clear. Since the distribution of the blood flow to the various vascular regions is controlled mainly by changes in the discharge frequency in the corresponding sympathetic nerves [1-3, 5-8], analysis of changes in efferent activity in the sympathetic nerve during stimulation of these structures is an essential preliminary to the assessment of the relative role of individual bulbar structures in the regulation of activity of the cardiovascular system.

Accordingly, the object of the investigation described below was to study efferent activity in the renal and splenic nerves during microinjection of acetylcholine (ACh) into the paramedian and ventral reticular nuclei.

EXPERIMENTAL METHOD

Cats were anesthetized with a mixture of chloralose (50 mg/kg) and pentobarbital (10 mg/kg), injected intraperitoneally. The stereotaxic coordinates of the paramedian and ventral reticular nuclei were determined

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