PATHWAYS OF ACTIVATION OF NEURONS OF THE MESENCEPHALIC RETICULAR FORMATION

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In acute experiments on curarized cats neurons of the mesencephalic reticular formation (RF) receiving afferent impulses via the lemniscal and spino-thalamic systems were investigated. Spike activity of single RF neurons was recorded extracellularly. After coagulation of the posteroventral lateral nucleus of the thalamus and blocking of the cortex by KCl application, activity of neurons responding to stimulation of the dorsal columns of the spinal cord could be recorded in the mesencephalic RF. It is postulated that neurons of the mesencephalic RF can be activated via collaterals of the medial lemniscus.

The problem of the afferent pathways by means of which information is transmitted to the reticular formation of the brain stem still remains unsolved despite many years of investigation. Contradictions are particularly apparent in connection with the pathways transmitting somatic afferent information to the reticular formation (RF).

Some workers consider that the main system of transmission of somatic information to the RF in the brain stem consists of the ventrolateral pathways of the spinal cord [5, 7, 10], while others [8, 13] indicate that afferent impulses can be transmitted into the mesencephalic RF along collaterals of the lemniscal pathways, while later investigations [4, 6] completely deny any participation of collaterals of the medial lemniscus in RF activation.

Bearing in mind the fact that the lemniscal system has already acquited a well-marked somatotopical organization even before its formation at the brain-stem level, namely in the dorsal columns of the spinal cord, and preserves this organization at subsequent levels [1], there are good grounds for considering that the collaterals of this system must also have a somatotopical distribution. In such a case, it could be considered that endings of the lemniscal collaterals in the brain-stem RF must preserve the somatotopical principle, i.e., that they must exhibit somatotopical projections. This, in fact, has never been observed, and most workers consider that the system of afferent projections in the brain-stem RF has a diffuse distribution. The view has been expressed that specificity of the incoming information is lost in the RF [3, 9, 11, 12].

The object of the investigation described below was to examine the possibility of conduction of afferent impulses to the mesencephalic RF along hypothetical collaterals of the lemniscal pathways and to determine the character of convergence of the lemniscal and spino-thalamic impulses on the common systems of neurons in the mesencephalic RF.

EXPERIMENTAL METHOD

Cats were anesthetized and immobilized with listhenon. Artificial respiration was applied. The animals were fixed in a stereotaxic apparatus, and painful points of fixation were infiltrated with procaine. The spinal cord was exposed at the level of the superior cervical segments and the tracts (dorsal columns

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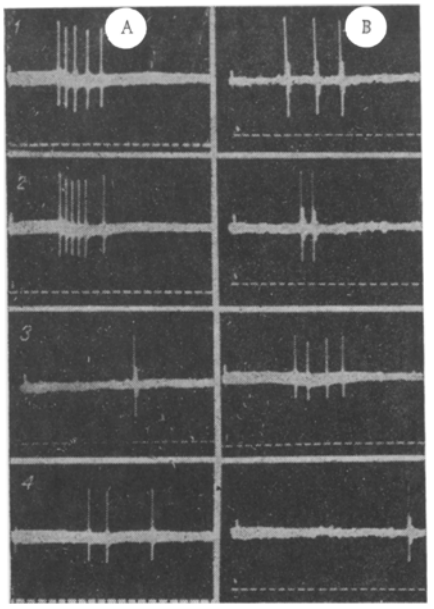

Fig. 1. Responses of mesencephalic RF neurons to stimulation of the limbs before (A) and after (B) division of dorsal column at the level C1-2: 1) stimulation of contralateral forelimb; 2) of ipsilateral forelimb; 3) of contralateral hind limb; 4) of ipsilateral hind limb.

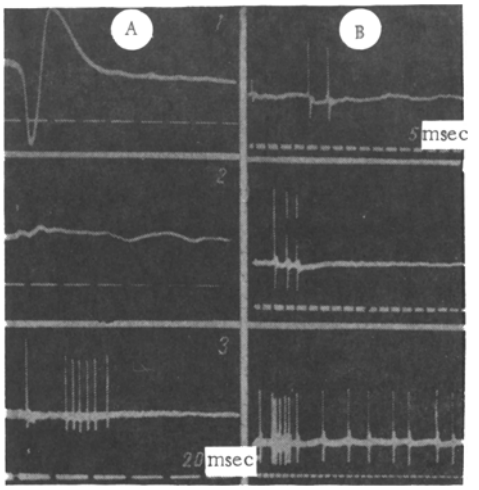

Fig. 3. Responses of mesencephalic RF neurons to stimulation of the dorsal columns. A) Different types of mesencephalic RF unit responses to stimulation of the dorsal column at the level C1-2. B: 1) evoked response from second cortical somatosensory area; 2) stimulation of dorsal columns after coagulation of VPL nucleus and application of KCl to the cortex; 3) response of mesencephalic RF neuron to stimulation of dorsal columns.

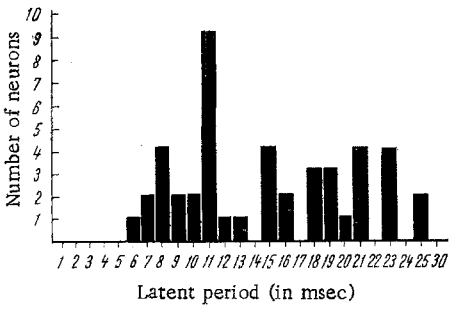

Fig. 2. Histogram of distribution of latent periods of mesencephalic RF unit responses to stimulation of the dorsal columns of the spinal cord.

of the spinal cord. Extracellular activity was recorded by glass microelectrodes (tip 1-2 μ in diameter, resistance 10-30 MΩ). Coordinates of the structures investigated were determined from the stereotaxic atlas of Jasper and Ajmone-Marsan (1954).

EXPERIMENTAL RESULTS

Of the 70 neurons investigated, 14 responded to stimulation of the nerve of the fore- and hind limbs on both contralateral and ipsilateral sides. In the case in which the tracts of the spinal cord were not divided, the latent period of the responses of these neurons was between 18 and 25 msec for the forelimbs and 25-30 msec for the hind limbs. When the dorsal columns were divided at the level of C1-2, the latent period of the responses reached 60-80 msec or more (Fig. 1).

According to data in the literature, an afferent impulse can reach the brain-stem RF through the relay nuclei of the thalamus and the cortex along the "cortical loop" [2]. After division of the dorsal columns, afferent impulses reach the mesencephalic RF only along the slowly conducting fibers of the ventral columns, thus explaining the difference between the latent periods of the RF unit responses before and after division of the dorsal columns of the spinal cord.

The same relationships also were observed in experiments in which the dorsal and ventral columns of the spinal cord were stimulated directly.

A histogram of the latent periods of the mesencephalic RF unit responses to stimulation of the dorsal columns is shown in Fig. 2. Clearly, there is a considerable scatter of the values of the latent periods of these responses – from 6 to 25 msec. It can be postulated that the RF neurons whose responses have a latent period not exceeding 8-10 msec are activated via the lemniscal system.

The different types of mesencephalic RF unit responses to stimulation of the dorsal columns are illustrated in Fig. 3.

It could be postulated that after blocking of the VPL and cortex, mesencephalic RF neurons will respond to stimulation of the dorsal columns with a latent period not exceeding 8-10 msec, for in this case an afferent impulse can reach the RF only via the collaterals of the medial lemniscus. In fact, the situation was somewhat more complex. After coagulation of the VPL nucleus and application of KCl to the cortex, the slow potential in cortical somatosensory zones 1 and 2 disappeared. This suggested that under these experimental conditions an afferent impulse did not reach the mesencephalic RF via the cortical loop. Nevertheless, in the experiments of this series 27 mesencephalic RF neurons responding to stimulation of the dorsal columns were recorded (Fig. 3B).

However, the latent period of the responses of these neurons was not 10-12 msec, but between 4 and 23 msec. In this particular case, these neurons can be regarded as having been activated along collaterals of the lemniscal pathways. The presence of neurons with a relatively long latent period (up to 23 msec) evidently suggests that in this particular case neurons receiving afferent impulses after a large number of relays in the mesencephalic reticular formation itself were recorded.

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