SPATIAL DISTRIBUTION OF FOCAL POTENTIALS IN THE VENTRO-LATERAL THALAMIC NUCLEUS EVOKED BY CUTANEOUS STIMULATION OF THE FORELIMB

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The distribution of focal potentials in the ventro-lateral nucleus (VL) of the thalamus evoked by stimulation of the contralateral somatic afferent systems was investigated in cats anesthetized with chloralose and pentobarbital. Evidence of a somatotopical distribution of afferent information in this nucleus was found. The responses to stimulation of the forelimb were distributed chiefly in the rostro-medial portion of the nucleus while responses evoked by stimulation of the hind limbs were located in the rostro-lateral portion.

The ventro-lateral nucleus of the thalamus (VL) is one of the more important centers for afferent interaction in the motor system of the brain. Many workers [1, 3, 6, 7] regard this nucleus as a relay system for the motor cortex. Electrophysiological investigations [2, 4, 6] have revealed some of the functional properties of this nucleus. For example, in response to stimulation of the limbs in cats short-latency evoked potentials with clearly defined configuration were recorded in VL [4, 9]. Similar investigations on monkeys [2] showed some features of a spatial distribution of somatic afferent impulses in that nucleus.

However, the problem of organization of the representation of somatic afferent systems in VL has not yet been specially studied. Meanwhile, the precise knowledge of the topography of somatic representation in this nucleus is necessary so that an idea can be obtained of the distinguishing features of the function of this nucleus, which has hitherto been regarded purely as a component in the system of cortico-cerebellar communication. The possibility cannot be ruled out that the relaying of somatic impulses in VL to those motor areas of the cortex to which cerebellar influences are directed may play an important role in the mechanisms of formation of fine adaptive responses in the motor system of the brain.

The object of this investigation was to study the spatial distribution of focal potentials in VL evoked by stimulation of somatic afferent systems.

EXPERIMENTAL METHOD

Acute experiments were carried out on anesthetized (pentobarbital 30 mg/kg, chloralose 50 mg/kg) cats using a stereotaxic technique. All painful points during fixation of the head were previously infiltrated with 1% procaine solution. To obtain complete immobilization, listhenon was injected intravenously and artificial respiration was applied. The skin of the limbs was stimulated with pulses of current (0.1 msec, 10 V) by means of bipolar steel needle electrodes. Focal potentials of VL were recorded by a monopolar nichrome electrode, with a tip 80μ in diameter. To determine the location of the tip of the recording electrode in VL histological sections were examined at the end of the experiment in the usual way. By moving

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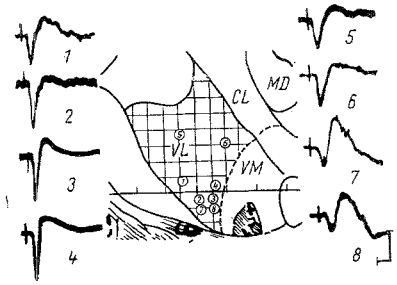

Fig. 1

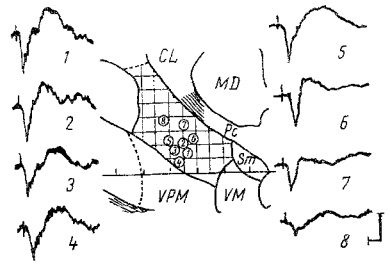

Fig. 2

Fig. 1. Map of distribution of evoked focal potentials in ventro-lateral thalamic nucleus. Frontal plane A-11. Numbers denote potentials recorded in corresponding parts of nucleus in response to stimulation of contralateral somatic afferents of forelimb. Calibration: 125 μV, 20 msec.

Fig. 2. Map of distribution of evoked focal potentials in ventro-lateral thalamic nucleus. Frontal plane A-10. Legend as in Fig. 1.

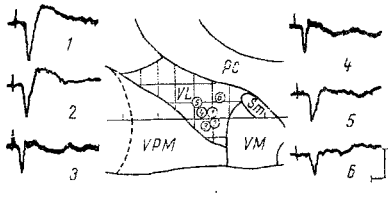

Fig. 3. Map of distribution of evoked focal potentials in ventro-lateral thalamic nucleus. Frontal plant A-9.5. Legend as in Fig. 1.

the recording electrode, various points in VL were investigated in all 3 stereotaxic planes and maps showing the distribution of somatic focal potentials in these points were drawn.

EXPERIMENTAL RESULTS

Characteristic focal potentials with an initial positive wave, followed by a slower negative wave, were recorded in VL in response to stimulation of somatic afferents of the forelimb. The mean amplitude of the positive wave was 125 μV in the focus, and its amplitude was 8-11 msec. On movement away from the focus the amplitude of the positive phase decreased, and its duration increased by 6-8 msec. These properties are characteristic of somatic focal potentials of the classical postero-ventral thalamic relay nucleus (VP). The only difference was a possibly rather lower amplitude. Since the positive phase of the focal potentials is regarded [1, 8] as a presynaptic process reflecting the discharge of afferent terminals, presumably the number of synchronously discharging terminals in VL is smaller than in VP. Such a relationship is perfectly likely if it is remembered that not all somatic afferent fibers reach VL, but only some of them, by contrast with VP.

The negative wave of the focal potential reached an amplitude of 50 μV and a duration of 18-36 msec. On removal of the electrode from the focus the wave became much smaller and could disappear completely. This shows that the tip of the recording electrode had moved away from neurons responding to the incoming afferent volley. Under these conditions a very small positive wave could still be recorded, for the presynaptic discharge was evidently stronger than the postsynaptic process developing in the neurons themselves.

The latent period of the focal potentials in the focus was 5-12 msec. On comparison with focal potentials recorded in VP in response to stimulation of the forelimbs [1, 2] it is evident that this short-latency response in VL can only be the result of direct activation of VL along fast-conducting somatic afferent systems. Consequently, there is every reason to suppose that somatic afferent information reaches VL as well as VP.

In frontal plane A-11 focal potentials evoked by stimulation of the forelimb (Fig. 1) reached their maximum at points 2, 3, and 4. When the electrode tip was moved, the configuration of the response changed (Fig. 1).

In frontal plane A-10 (Fig. 2), i.e., after shifting the electrode more caudally, the focus of maximal activity for potentials of the contralateral forelimb was situated in points 1, 2, and 3. Just as in the preceding

case, on movement of the electrode the focal potentials changed. More caudally still, for example, in frontal plane A-9, virtually no focal potentials could be recorded.

The morphological evidence [5] shows that this part of the nucleus contains smaller cells which are evidently unconnected with the relay function of this nucleus. Rather more rostrally, closer to plane A-10, where this parvocellular structure is not found, focal potentials were recorded relatively well. A group of such potentials recorded in frontal plane A-9.5 is illustrated in Fig. 3.

The results of the study of the topography of distribution of focal potentials in VL evoked by stimulation of the forelimb thus suggest that there are some features of a somatotopical distribution of somatic afferent systems in VL. At the points of the nucleus investigated practically no focal potentials were recorded in response to stimulation of the hind limb. These were represented more rostro-laterally to these regions.

LITERATURE CITED

1. R. A. Durinyan, The Central Structure of Afferent Systems [in Russian], Leningrad (1965), p. 67.
2. D. Albe-Fessard and D. Bowsher, Electroenceph. Clin. Neurophysiol., 19, 1 (1965).
3. B. Appelberg, Acta Physiol. Scand., 51, 356 (1961).
4. P. Dell, J. Physiol. (Paris), 44, 451 (1952).
5. J. Jansen and A. Brodal, in: Nervensystem, Berlin (1959), p. 323.
6. J. Kruger and D. Albe-Fessard, Exp. Neurol., 2, 442 (1960).
7. J. Massion, P. Angaut, and D. Albe-Fessard, Electroenceph. Clin. Neurophysiol., 19, 433 (1965).
8. V. B. Mountcastle and E. Henneman, J. Neurophysiol., 12, 85 (1949).
9. T. E. Starzl, J. Physiol. (Paris), 14, 479 (1951).