EXTRALEMNISCAL AFFERENT PROJECTIONS OF DORSAL COLUMN NUCLEI TO THE CONTRALATERAL VENTROBASAL THALAMIC NUCLEAR COMPLEX

T. V. Orlova, N. R. Pashina,
and N. N. Lyubimov

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Recovery of conditioned instrumental defensive and food reflexes involving the "forelimb" contralateral to the side of hemisection of the tegmentum mesencephali (TM) was found during previous years [13, 8]. Since as a result of this operation classical, including lemniscal, afferent projections of the contralateral forelimb were blocked, recovery of the above-mentioned reflexes could be explained by the existence of ascending extralemniscal afferent projections of the dorsal column nuclei of the spinal cord, which conducts kinesthetic sensation in the ipsilateral half of the brain stem up to the diencephalic level. The further course of these projections was unknown. However, it was assumed that extralemniscal afferent projections at the level of the diencephalon may be mediated by corresponding transcommissural connections, so that kinesthetic information would travel to the hemisphere which, as a result of this operation, was deprived of its classical lemniscal connection [4, 5]. The next step in the study of the distribution of the extralemniscal afferent projections of the forelimb at the diencephalic level was taken in [6]. According to the results of that investigation low-amplitude evoked response (ER) are recorded in the ventral posterolateral thalamic nucleus on the side of division of TM to stimulation of the contralateral forelimb, within the time interval of specific ER of these formations. This observation motivated a further more detailed study of extralemniscal afferent projections of the forelimb on structures of the contralateral ventrobasal nuclear complex (VNC) of the thalamus after surgical division of all ascending connections to it from the ipsilateral half of TM.

EXPERIMENTAL METHOD

Experiments were carried out on 8 cats before and after division of TM, in which ER were recorded to stimulation of the forelimbs during an acute experiment under pentobarbital anesthesia, with multiple stereotaxic insertion of the electrode in all frontal planes through VBC on both sides of the thalamus, with a distance of 1 mm between the recording points [6].

EXPERIMENTAL RESULTS

At many points of the thalamic VBC, contralateral to the stimulated forelimb and ipsilateral to the side of division of TM, low-amplitude ER were recorded within the time interval of specific ER of that structure to somatosensory stimulation (Fig. 1b). The latent period of these ER was 4-5 msec. These ER had two components: the first was electrically positive, the second negative. The duration of the first and second components of these ER varied from 7 to 12 msec, and their amplitude did not exceed 50 μV, i.e., they were about 8-10 times smaller in amplitude than ER at these same points of the thalamic VBC before the operation (Fig. 1a) and to stimulation of the contralateral forelimb. Thus VBC of the contralateral thalamus receives extralemniscal afferent projections of the forelimb. The low-amplitude ER in this structure, described above, are associated with them.

How do the extralemniscal afferent projections of the forelimb reach the contralateral thalamic VBC? They are evidently direct connections of the dorsal column nuclei of the spinal cord which ascend in the ipsilateral half of the brain stem toward the corresponding

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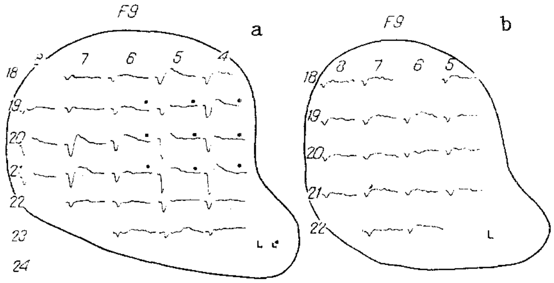

Fig. 1. Computer-averaged ER at different points of VCB of the thalamus to stimulation of the contralateral forelimb before (a) and after (b) division of the ipsilateral TM in an acute experiment on a cat. Monopolar derivation. Calibration: 50 μV, 10 sec.

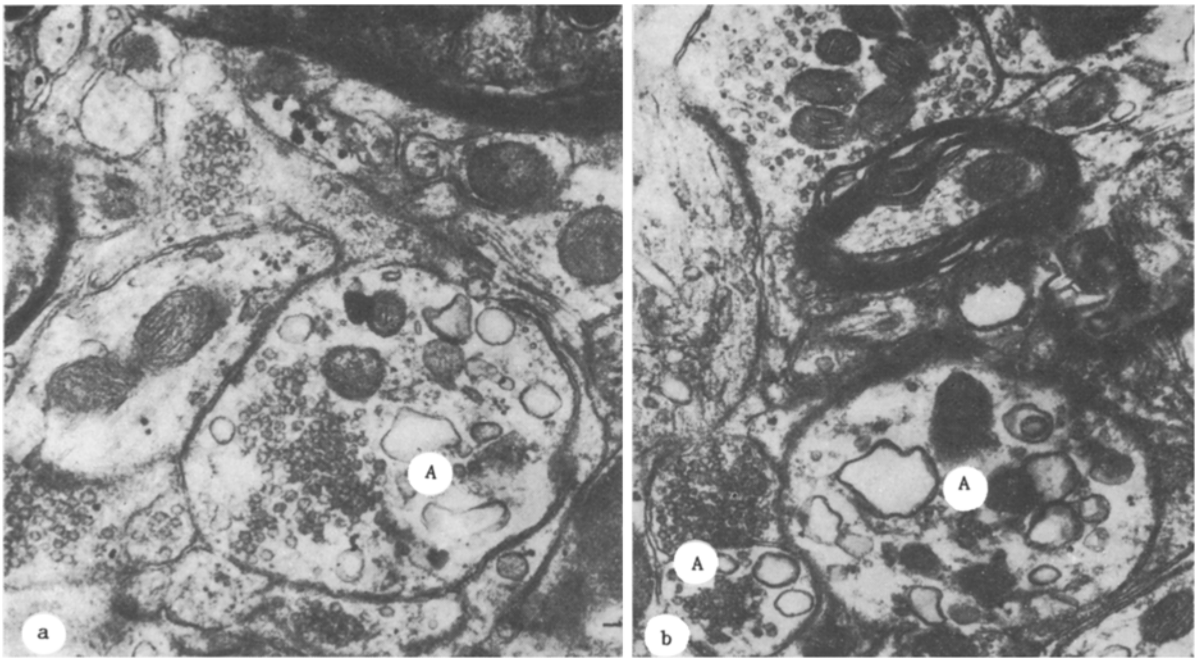

Fig. 2. Ultrastructural changes in axon (A) terminals in contralateral thalamic ventrobasal nuclear complex relative to side of hemisection of TM. a) Agglutination of synaptic vesicles, formation of membrane bodies, vacuolation; b) changes in size and shape of synaptic vesicles in medium-sized and small axon terminals. 30,000 ×.

thalamus, and they do not run into the classical lemniscal decussation at the medullary level. These connections pass through the commissural systems of the diencephalon (through the interthalamic, supramammillary, and posterior cerebral commissures), probably without synaptic relay in the ipsilateral thalamus, to the opposite side, forming a special decussation of extralemniscal afferent projections of the forelimb rostrally to the midbrain. Structural and functional confirmation of these arguments can be found in the literature [1, 7, 10, 11].

To provide a structural basis for this hypothesis, we made a parallel search for degenerative changes in axonal connections by electron microscopy in the contralateral thalamic VBC relative to the side of hemisection of TM in animals of another group (5 cats), on which the same operation was performed a short time previously. These experiments showed that direct connections ascend from tegmental structures of each half of the brain stem toward the contralateral thalamic VBC. Evidence of this is given by the results of our observations on degenerative changes in the axon terminals of this formation 5-7 days after the corresponding operation (Fig. 2a, b).

Extralemniscal afferent projections to structures of the contralateral thalamic VBC (their width, the stability of the characteristics of their ER, and so on), which we describe, raise the question of participation of these afferent projections in the recovery of kinesthetic sensation and of conditioned instrumental defensive and food reflexes on the contralateral side of the body relative to hemisection of TM. There is no doubt that these recovery processes are connected with functional mobilization of neuronal mechanisms in the contralateral half of the forebrain relative to the forelimb tested, where the sensory centers of kinesthetic sensation are located, together with the motor centers controlling that limb. The fact that extralemniscal afferent projections reach this part thus emphasizes to an even greater degree their role in recovery of kinesthetic sensation and of conditioned instrumental reflexes on the side of the body contralateral to hemisection of TM.

It is necessary to state why we describe the afferent projections of the forelimb to structures of the contralateral thalamic VBC after division of ascending connections from the ipsilateral TM to it as extralemniscal projections originating in the dorsal column nuclei of the spinal cord and running into the ipsilateral half of the brain stem, crossing to the opposite side at the diencephalic level, and not as the transcommissural continuation of ipsilateral spinoreticulothalamic and spinothalamic connections. The spinothalamic system is ill-defined in carnivores. Most of the data in the literature are evidence in support of this view [1, 4, 9, 12]. As regards the spinoreticulothalamic system, this has polysynaptic relays in the brain-stem reticular formation, and its functional influences reach structures in the forebrain after a latent period of 18-20 msec [2, 4]. We therefore rule out any role of the spinoreticulothalamic and spinothalamic systems in functional projections of the forelimb to structures of the contralateral thalamic VBC after surgical interruption of connections from the ipsilateral TM ascending to it. The same may also be said about the spinocervicothalamic system, which has no ipsilateral afferent projections to structures of the forebrain.

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