Cortical and Pallidal Projections to the Nucleus Ventralis lateralis Thalami

Electron Microscopical Studies in the Cat

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Received August 27, 1974

Summary. The nucleus ventralis lateralis (VL) and ventralis anterior (VA) thalami have been studied with the electron microscope following lesions of the cerebral cortex and of the nucleus entopeduncularis which represents the homologue of the medial pallidal segment in primates.

It has been confirmed that VL receives a substantial number of afferents from the motor cortex, while cortical fibers to VA originate mainly rostral to the precruciate gyrus. Corticofugal fibers terminate in VL/VA as type SR boutons (Rinvik and Grofová, 1974a) and establish synapses with relay cell dendrites and with vesicle-containing dendrites.

Four to five days following large lesions of the entopeduncular nucleus an electron-lucent form of degeneration occurs in one type of boutons in VL. These boutons are greatly swollen and vesicle-depleted, and contain altered mitochondria, an increased number of glycogen particles, irregular membrane structures and vacuoles. Some of the electron-lucent boutons progress into electron-dense forms at later survival times. Boutons showing these degenerative changes establish symmetrical synapses with relay cell dendrites and/or cell bodies. They do not synapse upon vesicle-containing dendrites and they are never engaged in the VL glomeruli. It is concluded that they belong to the type F1 boutons (Rinvik and Grofová, 1974a).

Similar initial electron-lucent changes are seen in boutons in the nucleus centrum medianum (CM) ipsilateral to the entopeduncular lesions. No evidence was found for a projection from the entopeduncular nucleus to VA.

The findings are discussed with regard to relevant morphologic and physiological data in the literature. Particular attention is paid to the interaction at the cellular level in VL between afferents from the intracerebellar nuclei, motor cortex and globus pallidus.

Key words: Thalamus — Nucleus entopeduncularis — Motor cortex — Experimental electron microscopy.

Introduction

In a previous electron microscopic study on the synaptic organization of the nuclei ventralis lateralis (VL) and ventralis anterior (VA) thalami in the cat, several types of boutons were described (Rinvik and Grofová, 1974a). One of them was identified as belonging to cerebellar afferent fibers (Rinvik and Grofová, 1974b). The present investigation was undertaken in order to find out which types of boutons in VL and VA belong to fibers originating in the cerebral cortex and the nucleus entopeduncularis.

The nucleus entopeduncularis is the feline homologue of the medial pallidal segment in primates and man (Fox et al., 1966; Grofová, 1970). The experimental studies by Nauta and Mehler (1966), Carpenter and Strominger (1967), Carpenter (1973), and Kuo and Carpenter (1973) established that only the medial segment of the globus pallidus projects to the thalamus in the monkey. Within the primate
thalamus the degenerating pallidofugal fibers appear to terminate within the principal (lateral) part of the nucleus ventralis anterior and in the oral and medial parts of the nucleus ventralis lateralis (terminology of Olszewski, 1952) as well as in the nucleus centrum medianum (CM) (Nauta and Mehler, 1966; Carpenter and Strominger, 1967; Carpenter, 1973; Kuo and Carpenter, 1973; Hassler, 1949, 1964, 1972).

Similarly detailed studies on the connections between the nucleus entopeduncularis and the thalamus have not been made in the cat. For this reason an experimental light microscopical study on the entopedunculothalamic projections was undertaken (Grofová, unpublished observations) and the preliminary results were used as a guide for the selection of blocks for the electron microscopical observation.

To the authors’ knowledge only one short communication has been published dealing with the ultrastructural identification of pallidal afferents in the monkey’s VL (Harding, 1973b). The findings to be reported in the present paper on the identity of boutons belonging to entopedunculothalamic fibers in the cat, differ fundamentally from those reported by Harding in the monkey (1973b).

**Material and Methods**

Altogether 13 adult cats of both sexes were used in this study. In 7 animals unilateral or bilateral (one case) lesions were made in the pericruciate region or in the cerebral motor cortex alone. Two of these animals were submitted to double operation consisting of a unilateral cortical lesion and a contralateral lesion of the nucleus entopeduncularis. Successful stereotaxic lesions of the nucleus entopeduncularis were made altogether in 8 cats. In three of these animals unilateral lesions of the nucleus entopeduncularis were combined with ipsilateral lesions of the cerebellar nuclei (see Rinvik and Grofová, 1974b), and in two with contralateral cortical lesions. Single or multiple stereotaxic lesions of the entopeduncular nucleus were made from the anterolateral approach with an electrode introduced at an angle of app. 30° to the horizontal plane. This approach was used in order to avoid damage to the thalamic nuclei and to the internal capsule by the needle track as well as in order to maximize the lateromedial extent of the lesions.

The animals survived from 4 to 34 days following the cortical lesions, and from 3 to 8 days following the entopeduncular lesions.

Perfusion techniques, selection of the blocks and further processing of the material for electron microscopy were described in previous papers (Rinvik and Grofová, 1974a, b). Histological controls of the lesions were made in all cases.

The contralateral thalamus was treated in the same way and was used in previous studies as normal (Rinvik and Grofová, 1974a) or experimental (Rinvik and Grofová, 1974b) material, and also served as a control for the evaluation of the tissue preservation. This procedure was considered safe since the primary motor cortical and pallidal projections to VL are strictly ipsilateral (Nauta and Mehler, 1966; Rinvik, 1972; Carpenter, 1973; Kuo and Carpenter, 1973).

**Results**

**Cortical Lesions**

Following lesions of the pericruciate gyri or of the cerebral motor cortex alone, the distribution within the thalamus of the degenerating fibers in p-phenylenediamine stained semithin sections is similar to that described in silver impregnated experimental material (Rinvik, 1972). Only when the cortical lesion extends rostral to the pericruciate gyri are degenerating fibers seen in VA to any considerable degree.