Specific Patterns of Neuron Arrangement and of Synaptic Articulation in the Medial Geniculate Body

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Summary. Golgi and electron microscopic analysis of the known cellular layers in concentric shells of the ventro-lateral portion of the medial geniculate body revealed a flat grid of high density neuropil filling the space between the geniculocortical relay cells, forming essentially a single cell layer in each lamina. The “skeleton” of this neuropil grid is made up by the interdigitating dendritic tufts of the geniculocortical relay cells, joined together by a rich system of desmosomoid adhesion plaques. The “holes” of the “skeleton” are filled in by the multilobed dendritic appendages of Golgi type II interneurons and the grape-like terminals of the inferior collicular specific afferents. Additional axon terminals of other sources – terminals of descending corticogenicular fibers, axons of the Golgi type II interneurons and terminals of the initial collaterals of the geniculocortical relay cells – contribute only to a very insignificant fraction of neuropil volume. The Golgi type II interneurons are oriented in perpendicular direction to the cell layers so that they may bridge with their dendrites several successive layers.

Although the general expression “synaptic glomeruli” used in other relay nuclei for this type of specific synaptic arrangement is hardly applicable to this grid-like neuropil, the essential synaptic articulation pattern of all thalamic relay nuclei is well maintained. The specific inferior collicular afferents are presynaptic to both relay cell dendrites and to the multilobed dendritic appendages of Golgi type II cells, which in turn are presynaptic to the same dendritic regions of the relay cells receiving the bulk of the specific afferents.

Key words: Medial geniculate body – Neuronal geometry – Synaptic triplets – Cat.

Introduction

Although the medial geniculate body (MGB) has been known for long to be an essential subcortical area in the auditory system, apart from classical studies on
the cytoarchitectonical parcellation (Münzer and Wiener, 1902; Ramón y Cajal, 1911; Nissl, 1913) the MGB has not attracted much attention until fairly recently, in contrast to its counterpart in the visual system. Thus, the general characteristics as well as the arrangement of relay cells had been described (Ramón y Cajal, 1911; Morest, 1964, 1965) and the attention was already focused on the specific dendritic protrusions representing the main postsynaptic loci in the complex synaptic glomeruli (Majorossy and Réthelyi, 1968; Jones and Powell, 1969a; Szentágothai, 1970).

The presence of short-axon interneurons (Ramón y Cajal, 1911) and their participation in the neuronal network of the MGB (Majorossy and Réthelyi, 1968; Morest, 1971) gained particular significance in the light of electrophysiological studies on the mechanism of sensory transmission (Andersen et al., 1964; Aitkin and Dunlop, 1969). The origin of ascending as well as descending afferents seems to be well established (Majorossy and Réthelyi, 1968; Jones and Powell, 1969b; Diamond et al., 1969; Jones and Rockel, 1971), although the essential design of their synaptic articulations is still little known.

Recent progress in neurobiology over the past decade, however, has fundamentally changed the concept of dendritic function generally valid for the understanding of dendrodendritic interaction (Rall et al., 1966; Shepherd, 1970, 1971) and demands also the reassessment of the modus of synaptic linkage in the neuronal network of the relay nuclei. The present study aims to point at finer details in spatial distribution, neighbourhood relations, structural peculiarities and synaptic design among the neuronal elements of the MGB, which are functionally meaningful and appear to be ubiquitous particularly in the sensory system.

**Material and Methods**

Adult cats and 6 week old kittens were used in this study. For the investigation of the normal neuronal structure at the light microscope level the rapid Golgi method and its modifications were suitable and preference was given to the perfusion Golgi-Kopsch technique for its superiority in staining the finest axon terminals in the mature brain. For electron microscopy normal animals were perfused under anaesthesia transcardially with double aldehyde mixture containing 4% paraformaldehyde and 1% glutaraldehyde buffered with 0.4 M phosphate solution to keep the pH at 7.4. Small pieces of brain tissue carefully oriented were dissected, postfixed in 2% osmic acid and embedded in Araldite. Semi-thin sections cut with the LKB ultrotome were stained with toluidine blue, while the thin sections contrasted with lead citrate as well as uranyl acetate were examined under the electron microscope Tesla BS 413.

The required localization of the material taken from the brain slices was chequed by serial sections stained with cresyl violet. The experimental approach was based on the surgical removal and on stereotactically placed complete or partial electrolytic lesions of the subcortical auditory nuclei, i.e. inferior colliculus, dorsal nucleus of the lateral lemniscus, superior olivary complex, cochlear nuclei. The postoperative survival time ranged from two to five days. The experimental material was investigated under the electron microscope as well as processed according to Fink and Heimer (1967) and Nauta and Gygax (1954) on frozen sections for light microscopy.