Connections between pericruciate cortex and the medullary reticulospinal neurons in cat: an electrophysiological study

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Summary. The connections between the pericruciate cortex and the medullary reticulospinal (RS) neurons were studied in anesthetized cat. Intracellular recordings were made from reticulospinal neurons and the effects of stimulating different areas of the pericruciate cortex were compared. (1) EPSPs were elicited in all the 93 neurons studied which were antidromically activated by spinal stimulation and had an IS-SD notch on the ascending limb of their antidromic spikes. According to the conduction velocity (c.v.) of the axon and the minimal EPSP latency to cortical stimulation, the neurons could be divided into two groups, i.e. fast-conducting RS neurons (FRS neurons, c.v. > 45 m/s) and slow-conducting RS neurons (SRS neurons, c.v. < 45 m/s). The minimal latencies of FRS neurons were equal to or shorter than 2 ms whereas those of SRS neurons were longer than 2 ms. (2) EPSPs with short latency (< 2 ms) could be evoked in FRS neurons by stimulating a relatively wide cortical area including the major part of precruciate area 4 and area 6, with a central area of strongest excitatory effect located in area 4 slightly medial to the tip of the cruciate sulcus. Stimulation of the postcruciate area 4 only produced long latency EPSPs. (3) By extrapolation from the cortical and peduncular latencies and the conducting distances it was revealed that the earliest part of the minimal latency EPSPs were monosynaptically evoked in FRS neurons and could be mediated by fast-conducting corticobulbar fibers. (4) FRS neurons could be excited by stimuli applied to both ipsilateral and contralateral pericruciate cortex. The influence from the contralateral cortex was slightly stronger.

Key words: Motor cortex – Reticulospinal neuron – Corticobulbar pathways – Cat

Introduction

The medullary reticular formation is an important center for control of movement, especially of the axial and proximal limb joints. Earlier anatomical and physiological studies have demonstrated that the medullary reticular formation receives projection from wide areas of the cerebral cortex (Rossi and Brodal 1956; Magni and Willis 1956). From the point of view of movement control, the connection between the motor cortex and reticular formation is of particular interest. Previous anatomical investigations with anterograde degeneration methods as well as HRP retrograde transport indicate that in the cat most corticoreticular neurons are concentrated in area 6 of the cerebral cortex (Kuypers 1958; Berrevoets and Kuypers 1975). However, a recent report emphasizes the importance of the adjacent area 4 in the anterior sigmoid gyrus (Keizer and Kuypers 1984). The present investigation was therefore undertaken to verify this problem with physiological methods. A brief account of this study has been published elsewhere (He and Wu 1982).

Material and methods

Preparation

32 adult cats were used in the experiments. Animals were anesthetized with Nembutal (40 mg/kg body weight). Supplemental injections of anesthetics were given every 4 to 6 h. The head of the animal was fixed to a stereotaxic apparatus with a forward tilt of about 14° to the horizontal plane. During recording, galamine triethiodide was injected and the animal was maintained with
artificial ventilation. Bilateral pneumothorax was also performed. The cerebellum was removed with suction to expose the bottom of the fourth ventricle. The C₃-C₄ segments of the spinal cord and the cerebral cortex around the cruciate sulcus were also exposed. All wounds were protected with warm paraffin oil. The arrangement of the experiments is illustrated in Fig. 1A.

Stimulation and recording

A pair of silver stimulating electrodes placed under the ventral surface of the C₃-C₄ segments of spinal cord were used for antidromically activating the reticulospinal neurons. The distance between the electrodes was 8–12 mm. A plastic sheet was used to separate the electrodes from the underlying tissues.

In order to observe the effects of cortical stimulation, two series of experiments were conducted. Six silver ball cortical stimulating electrodes were placed in cerebral peduncle (CP). III. Recording microelectrode. IV. Stimulating electrodes on the spinal cord (SC). B Arrangement of cortical stimulating electrodes on the right pericruciate cortex in Experiment I. Three monopolar stimulating electrodes are placed on points A–C respectively. C Placement of cortical stimulating electrodes on the right cortex in Experiment II. Four electrodes are placed on points a–d respectively. Dashed lines in B and C outline the cytoarchitectural areas 4 and 6 according to Hassler and Muhs-Clement (1964)

Results

1. Identification of RS neurons

Two criteria were used to identify a unit as a RS neuron: 1. An intracellularly recorded antidromic spike was elicited by spinal cord stimulation. The antidromic nature of the response was determined according to the invariable latency, the abrupt rise of the spike from the base line and, tested in some cases, the frequency following up to 100 Hz. 2. An IS-SD notch was found on the ascending limb of the antidromic spike. In medial reticular formation of the medulla it was relatively easy to obtain a stable recording from units which had no IS-SD notch on the ascending limb of the spike but responded "antidromically" to spinal stimulation. Injection of horseradish peroxidase into 7 units of such kind through the recording microelectrode revealed that only axon and collaterals were stained, indicating that the microelectrode tip was in the axon, although one of the units had an EPSP of 1.1 mV to cortical stimulation. Injection of horseradish peroxidase into 7 units of such kind through the recording microelectrode revealed that only axon and collaterals were stained, indicating that the microelectrode tip was in the axon, although one of the units had an EPSP of 1.1 mV to cortical stimulation. Another unit, whose soma and dendrites were well stained, had a clear IS-SD notch in its antidromic spike. In view of this finding, and of the fact that an EPSP could be recorded from an axon even when the microelectrode tip was several millimeters away from the soma (Gogan et al. 1983), second criterion was also adopted in the present