The Ventral Spino-Olivocerebellar System in the Cat. I. Identification of Five Paths and their Termination in the Cerebellar Anterior Lobe

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Summary. 1. The spino-olivocerebellar paths ascending through the ventral funiculus (VF-SOCPs) and projecting to the cerebellar anterior lobe were investigated in cats with the spinal cord transected in the third cervical segment sparing only the ventral funiculus on one side. The climbing fibre responses evoked in Purkinje cells by limb nerve stimulation were studied by recording the mass activity at the cerebellar surface or in the molecular layer.

2. Five VF-SOCPs were distinguished on the basis of their receptive fields, response latencies, and projection areas.

3. The projection areas consist of narrow sagittal zones. Three zones (a, b₁ and b₂) lie in the vermis and extend throughout lobules II–V. Two zones (c₁ and c₃) lie in the pars intermedia and are restricted to the classical hindlimb area, lobules II–IV. The VF-SOCPs are labelled according to their termination zones: a-VF-SOCP, b₁-VF-SOCP, etc.

4. The a-, c₁- and c₃-paths are activated from the ipsilateral hindlimb, whereas the b₁- and b₂-paths are activated bilaterally from the forelimbs and hindlimbs, respectively. The latencies of the responses evoked from the ipsilateral hindlimb are relatively short for the c₁-path and successively longer for the c₃-, b₂- and a-paths.

5. The olivary transmission showed fluctuations in efficacy independent for the different VF-SOCPs. The effect of anaesthetics on this transmission also differed between the paths.

6. It is concluded that the five VF-SOCPs relay in different compartments of the inferior olive which are tentatively identified.

Key words: Ventral spino-olivocerebellar paths – Climbing fibres – Inferior olive – Cerebellum – Sagittal organization

Introduction

The projection areas of the many spino-olivocerebellar paths (SOCPs) form narrow sagittal zones in the cerebellar anterior lobe as demonstrated by the distribution of evoked cortical potentials (Oscarsson 1969b, 1973, 1976). These
zones are indicated in the diagrams of Figure 6A–C and identified by letters and indices using a nomenclature modified after Voogd (1969) who described similar zones on the basis of observations on the fibre compartments in the cerebellar white matter and the corticonuclear connections. Each zone is innervated by climbing fibres originating from a separate compartment of the inferior olive represented by a small circumscribed region of the nucleus (Armstrong, Harvey and Schild, 1974; Groenewegen and Voogd, 1976a; Brodal and Walberg, 1977). Each olivary compartment receives a unique input from two or three spinal paths and from the motor cortex (Miller, Nezlina and Oscarsson, 1969; Oscarsson, 1976). The SOCPs are divided into groups ascending through the different spinal funiculi (DF-SOCPs through the dorsal funiculus, VF-SOCPs through the ventral funiculus, etc.). The SOCPs in each group are defined by their projection zones in the cerebellar cortex using the letters and indices shown in Figure 6A (Oscarsson, 1976).

It has been suggested that each sagittal zone represents a functional unit controlling a special motor mechanism (Oscarsson, 1969b, 1973, 1976). The climbing fibre path originating from a certain olivary compartment usually reaches only one sagittal zone and presumably carries information closely related to the particular motor function of that zone. The observations made by Voogd (1969) suggest that each zone has its own efferent path through which it may exert its motor control.

Knowledge of the functional organization and termination of the SOCPs is a pre-requisite for understanding the function of the sagittal zones in the cerebellar cortex and we have now made a systematic study of the SOCPs ascending through the ventral funiculus of the spinal cord (VF-SOCPs). These paths are unique among the SOCPs in that the spinal afferents make monosynaptic contacts with the olivary neurones (Brodal, Walberg and Blackstad, 1950; Oscarsson, 1968, 1973). The paths cross the midline twice: at the segmental level and after the olivary relay. It will be demonstrated that the organization and termination of the VF-SOCPs are much more complex than assumed in an earlier, preliminary study (Oscarsson, 1968). Five VF-SOCPs can be distinguished on the basis of their receptive fields, segmental organization and termination zones in the cerebellar cortex. Collectively these paths will be denoted the ventral spino-olivocerebellar system.

The first two papers in this series will be devoted to the identification of the different VF-SOCPs and their termination zones in the anterior (this paper) and posterior lobes (Oscarsson and Sjölund, 1977a). In the following papers the segmental organization and supraspinal control will be described, leading to a hypothesis of the information carried by the paths (Oscarsson and Sjölund, 1977b; Andersson and Sjölund, 1977; Sjölund 1977). Some of the findings were described in a preliminary paper (Oscarsson and Sjölund, 1974).

Methods

The experiments were performed on 31 cats, 2–3 kg of weight. Three types of preparations were used for the present experiments: a) intact animals anaesthetized with sodium pentobarbital