Monosynaptic Excitation of Spinal γ-Motoneurones from the Brain Stem

It has been reported that in contrast to α-motoneurones there is no monosynaptic excitatory action from primary afferents to γ-motoneurones which receive spinal reflex actions through relatively complex pathways[1,2]. On the other hand, the driving effect on muscle spindle afferents evoked from the brain stem may indicate a simpler linkage between descending fibres and γ-motoneurones[3]. It has now been found that large monosynaptic EPSPs can be evoked in γ-motoneurones by impulses in fibres descending from the brain stem.

The experiments were made on adult cats anaesthetized with pentobarbitone-sodium. Glass capillary microelectrodes (filled with 2*M* K-citrate or 3*M* KCl solution) were inserted at the lumbar level into the motor nucleus of the ventral horn, and γ-motoneurones were recorded intracellularly. Motoneurones, as determined by an antidromic invasion from the muscle nerves or the ventral roots, were identified as γ-motoneurones either by the slow conduction velocity of the axon (when the ventral roots were intact) or, in a few cases (when the ventral roots were cut for antidromic stimulation), by the lack of monosynaptic EPSP from the primary afferents even with strong stimulation of the whole dorsal roots of the same and neighbouring 2 segments. The neurone illustrated in the Figure A–I was identified in the latter way; A and B show that the neurone was excited from the ventral roots in an all-or-none fashion without graded prepotentials.

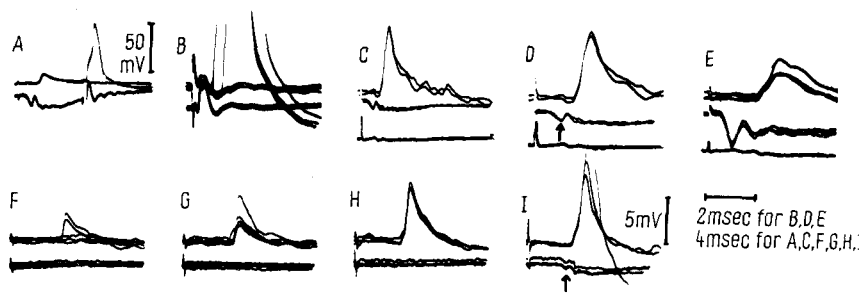
An EPSP of a simple configuration was induced by a single shock stimulation both from the ipsilateral spinal cord (C, D, 9.5 cm rostral to the recording site) and from the lower brain stem (F–I), the latter being stimulated by a tungsten electrode stereotactically placed by means of a Horsley-Clarke apparatus. The time course and the maximal amplitude of the 2 kinds of EPSPs were very similar, suggesting that the EPSPs are mediated by the same fibre system continuing from the brain stem down to the lumbar cord. The conduction velocity of the descending tract is estimated to be 90 m/sec.

The latency of the EPSP was fixed and short. The shortest segmental delay may be less than 0.4–0.5 msec, which was the interval between the onset of the negative deflection in the cord dorsum potential (indicated by arrow) and the onset of the EPSP. The EPSP followed a stimulus frequency of more than 400 c/sec. These features strongly suggest a monosynaptic nature of the EPSP.

Careful adjustment of the stimulus strength showed that the size of each unitary EPSP may be as large as 2.0–2.5 mV (F, G) and that a full-sized EPSP is composed mainly of a limited number of these large unitary EPSPs. The amplitude of the maximal monosynaptic EPSP reached 8–10 mV and could initiate a spike potential (I).

Stimulation of the contralateral spinal cord (8–10 cm rostral to the recording site) also induced EPSPs with a short latency. However, the segmental delay was 0.9–1.0 msec and slightly (0.4–0.5 msec) longer than that from the ipsilateral cord, suggesting a disynaptic linkage or possibly an involvement of slower conducting fibres.

We were unable to evoke the distinct monosynaptic EPSP from the brain stem in about half the γ-motoneurones examined. A possibility may be envisaged that those two kinds of γ-motoneurones distinguished by the presence or absence of the supraspinal monosynaptic EPSP correspond to static and dynamic γ-motoneurones[4–6].



Each record in upper traces shows intracellular recordings from a γ-motoneurone. Lower traces in A, B, F–I and middle traces in C–E are recordings from L7 dorsal root entry zone. Lower traces in C–E show potentials recorded with the microelectrode at a just extracellular position. A, B show antidromic invasion from the L7–S1 ventral roots. C, D show effects of stimulation of ipsilateral spinal cord at lower thoracic level, E after stimulation of contralateral spinal cord at the same level (dorsal columns were removed for 2 segments at the level of stimulation). F–I show EPSPs after stimulation of the ipsilateral lower brain stem at different strengths. Voltage calibration at A refers to this record only. Spike potentials in B and I are retouched.

Zusammenfassung. Während Reizung des caudalen Hirnstammes wurden durch intrazelluläre Ableitung mit Mikroelektroden monosynaptische EPSPs in lumbosakralen γ-Motoneuronen registriert.

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