17154. Small-nerve Fibers in Mammalian Ventral Roots.*

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The function of the frogs small-nerve motor system has been studied in detail during the last few years.[1-4] Slowly conducting high threshold nerve fibers of around 5 μ in diameter emerge through the ventral roots and innervate numerous muscles in the body. On stimulation they cause local graded contractions around the neuromuscular junction, depending on the frequency of stimulation. The frogs small-nerve system also shows a distinct reflex pattern.

In the cat about 25 per cent of the nerve fibers in the ventral roots of the lumbosacral region are medullated fibers of small diameter with a distribution peak of 4-6 μ.[5] Their physiological properties have been studied by several investigators.[4,6,7] In particular Leksell[8] concluded that the effect of the small-nerve fibers on the contractile mechanism was small or absent and that the fibers influenced the afferent discharge from muscle proprioceptors.

A systematic investigation was made of the function of ventral root nerve fibers to the soleus and tenuissimus. By subdividing ventral roots into fine filaments individual nerve fibers innervating different muscles were obtained. The nerve fibers were then stimulated singly or together at varying frequencies and their effect was determined on the contractile and sensory mechanism of the muscles. Nerve fibers conducting at speeds faster than 50 m/sec caused the well known motor unit response, *i.e.* twitches and propagated muscle impulses. Nerve fibers conducting between 16-50 m/sec. caused no detectable muscle shortening and no propagated muscle impulses. Calculations of diameters from conduction velocities in the small-nerve group showed a distribution in agreement with histological data (3-8 μ, cf[5]).

The sensory discharges of muscles could be detected by recording from the surface of the tenuissimus, from nerve branches emerging from muscles, or preferably by isolating filaments of dorsal roots, containing a single nerve fiber from the muscle under study. The latter method gave simple and clear-cut indication of the sensory discharge regulation in muscle spindles, since a single efferent fiber to a muscle spindle could be stimulated and its effect recorded in a single sensory fiber. Different discharge patterns discovered by Matthews[9] were easily detected and his findings of A_1, A_2 and B discharge types were readily confirmed in numerous observations.

Stimulation of the small ventral root fibers, when effective, increased the afferent discharge from muscle spindles, dependent upon the tension of the muscle and the duration and frequency of stimulation. The increase could be elicited from spindle receptors which showed a steady rate of discharge or from receptors which showed no resting discharge at a given initial tension. The principal feature of the small-nerve mechanism is illustrated in Fig. 1, which shows that the sensory discharge can be finely regulated by adjustment of muscle tension and by motor excitation of the spindle intrafusal fibers. In A, B, and C it is shown that the discharge is not directly proportional to the

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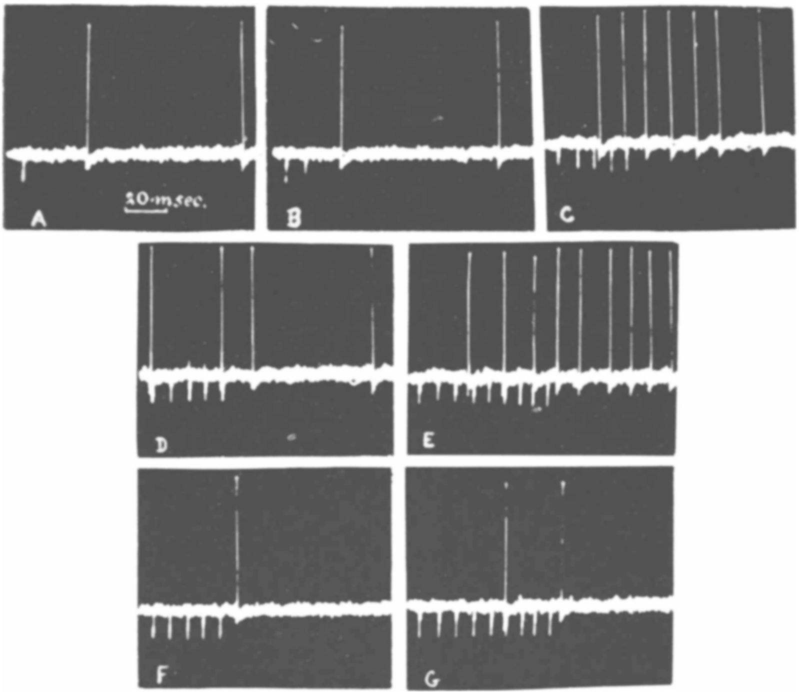

FIG. 1.

Small-nerve fiber stimulation in ventral root, recording from dorsal rootlet. Single fiber afferent discharges from soleus at varying muscle tensions. Stimulus intervals are 9 msec.

A, B, and C—Muscle tension 40 g. In A and B 2 and 3 stimuli set up 2 sensory spindle discharges. C. 6 stimuli cause a train of responses.

D and E—Tension 20 g. D. 6 stimuli as in C now set up fewer discharges. E. 10 stimuli restore longer train of discharges.

F and G—Zero tension. 6 and 10 stimuli are practically ineffective. Occasional resting discharges occurred at 40 and 20 g muscle tension.

number of stimuli but shows a mechanism of facilitation. Lowering the muscle tension renders the spindle less sensitive to small-nerve excitation, but at intermediate tensions an increase in number of stimuli can compensate for such an effect (C + E). However, at zero muscle tension even prolonged stimuli remain practically ineffective. The spindle of Fig. 1 gave an A_1 type response as described by Matthews. Its discharge showed a high threshold to stretch.

The facilitation mechanism of spindle discharge and other data suggest that the small-nerve fibers in the cat cause local contractions in intrafusal muscle fibers. This would be analogous to the graded contractile responses in frog striated muscles, innervated by the small-nerve motor system.

Besides the small-nerve innervation described here, many spindle intrafusal fibers are supplied by motor nerves of larger diameter as originally found by Matthews (cf also[10]). The latter cause a discharge pattern which is in contrast to the one illustrated in Fig. 1 in that a single nerve impulse sets up a burst of sensory discharges.

Summary. The lumbosacral ventral root outflow of the cat contains 20-25 p.c. small diameter nerve fibers. These cause no detectable shortening of muscles and no propagated muscle impulses. Stimulation of such fibers sets up discharges from muscle spindle receptors. The discharge is dependent upon the number and frequency of stimuli and on adjustment of muscle stretch.

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