

Effects of Hindlimb Cutaneous Afferent Inputs on Spinal Reflex Recording from Tail Muscle Motoneurons in the Spinalized Cat

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ABSTRACT. In 4 spinalized cats, the effects of afferent inputs from hindlimb cutaneous nerves (sural cutaneous nerve: Sur) on mono- and poly-synaptic reflex recorded from tail muscle motoneurons were studied before and after spinal lesioning at S2–3 level. Monosynaptic reflex was enhanced by ipsilateral Sur stimulation at short conditioning-test stimulus interval and this effect was not observed after spinal lesion of ipsilateral side of spinal cord. Polysynaptic reflex was inhibited by stimulation of Sur in both sides and this inhibitory effect was depressed by contralateral spinal lesioning.—**KEY WORDS:** hindlimb, motoneuron, tail.

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We have been studying the neural control of tail movements in the cat [4–9] and our results suggest that various descending and propriospinal pathways influence tail movements [4, 8]. To understand the neuronal control of tail movements, it is necessary to determine the role of various neuronal pathways. In the present experiments, we studied the neuronal pathways from hindlimb cutaneous afferent nerves to the tail muscle motoneurons.

Experiments were performed on 4 adult long-tailed cats weighing 2.3–3.4 kg that had been decerebrated and spinalized at L1–L2. The animals were paralyzed with Pancuronium bromide (0.4 mg/kg) and artificially ventilated. End-tidal CO₂ concentration was monitored and maintained at approximately 4.0±1.0% by adjusting the respiratory rate and tidal volume. The rectal temperature was maintained close to 37°C with a heating mat. Arterial blood pressure was usually above 80 mmHg. We stopped experiments when arterial blood pressure got to be below 80 mmHg. Laminectomy was performed between L5 and sacral vertebrae. The dorsal roots from S1 to Co 3 were cut and the Co 1 dorsal root was prepared for test stimulation with bipolar silver electrodes. The muscle nerve innervating m. extensor caudae lateralis (ECL) was prepared and mounted on bipolar electrodes for recording. The spinal reflex induced by Co 1 dorsal root stimulation as recorded from ECL. Test stimulation of the Co 1 dorsal root was performed using a single pulse (duration: 0.1 ms). The intensity of the stimulation was adjusted to 3 times the intensity that induced a minimum spinal reflex. Three cutaneous nerves innervating hindlimb, sural cutaneous nerve (Sur), superior peroneal cutaneous nerve (SPc) and the cutaneous nerve innervating planter part of hindfoot (Tib), were prepared and mounted on bipolar electrodes for conditioning stimulation. Conditioning stimulation of cutaneous nerve was electrically performed by triple train pulse (duration: 0.1 ms, interval: 2 ms, intensity: 1.2–10T). Intervals between first pulse of conditioning stimulation and test stimulation were 10, 20, 30, 40, 50, 70, 100, 200 and 300 ms. The recorded mono- and polysynaptic reflexes were averaged 8 times using a signal processor (7T17, NEC Sanei). The magnitude of the mono- and polysynaptic reflexes was determined by measuring the area of the peaks of the integrated reflexes and effects of conditioning stimulation

was indicated as a percentage compared to the unconditioned control reflex size (=100%). Spinal lesioning was performed using forceps.

Figure 1 shows the typical effects of Sur stimulation on ECL mono- and polysynaptic reflexes. The effects of SPc

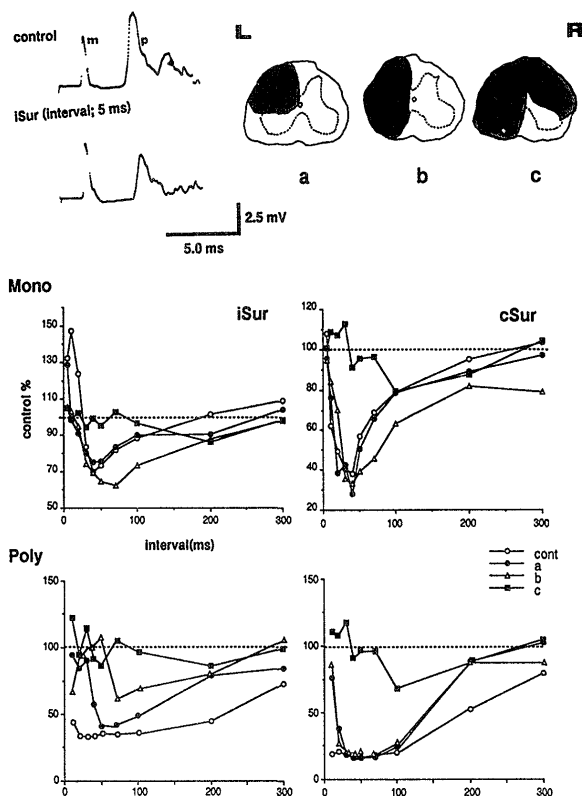


Fig. 1. Effects of Sur nerve stimulation on both sides on the ECL monosynaptic reflex before and after spinal lesioning. In the upper left panel, the effects on ECL monosynaptic (m) and polysynaptic (p) after conditioning stimulation of the ipsilateral Sur (iSur) at 5.0 ms intervals. The monosynaptic reflex was enhanced and the polysynaptic reflex was inhibited by conditioning stimulation of iSur at 5.0 ms interval. In the lower panel, the effects of ipsilateral (iSur) and contralateral Sur (cSur) stimulation at various intervals before (cont) and after spinal lesioning (a, b, c). In the upper right panel, the spinal lesions are indicated by hatched areas. See text for details.

and Tib stimulation before and after spinal lesioning were similar to those of Sur stimulation. In the upper left, the averaged spinal reflexes recorded from ECL muscle nerves are shown. After conditioning stimulation of Sur (interval; 5.0 ms), the monosynaptic reflex (m) was enhanced (113%) and the polysynaptic reflex (p) was inhibited (59%). In the upper right, areas of spinal lesioning are shown as hatched areas. In the lower panel, effects of ipsilateral (left side) and contralateral (right side) Sur stimulation on monosynaptic (Mono) and polysynaptic reflexes (Poly) are shown before and after spinal lesions a, b and c. Before spinal lesioning, monosynaptic reflexes were enhanced by iSur stimulation at 5–20 ms intervals and inhibited at 30–100 ms intervals, while polysynaptic reflexes were inhibited at 5–300 ms intervals. After conditioning stimulation of cSur, monosynaptic reflexes were inhibited at 10–300 ms interval and polysynaptic reflexes were strongly inhibited at 5–300 ms intervals. The excitatory effects after iSur stimulation was weakened by spinal lesioning of the dorsal quadrant of ipsilateral side (lesion-a) and disappeared after hemisection on the ipsilateral side (lesion-b). The inhibitory effects of iSur stimulation were not influenced by lesion-a, were enhanced by lesion-b and strongly depressed after lesion-c. The inhibitory effect of cSur stimulation on monosynaptic reflex was not influenced by lesion-a or b, and became weaker after lesion-c. The inhibitory effects of iSur stimulation on polysynaptic reflex were depressed by spinal lesion-a, b and c at 50–100 ms interval, while the inhibitory effects of cSur stimulation on polysynaptic reflex was not influenced by spinal lesion-a or b, but had almost vanished after lesion-c. The present experiment clearly shows the existence of excitatory and inhibitory neural pathways from hindlimb cutaneous nerves to tail muscle motoneurons. Furthermore, the results using spinal lesioning indicate that excitatory and inhibitory

neural pathways mainly pass through ipsilateral and contralateral side of spinal cord at S2–3 level, respectively. The monosynaptic reflex was enhanced and inhibited by stimulation of ipsilateral and contralateral cutaneous nerves at short conditioning-test stimulus interval, respectively. The activity of ECL produces dorsolateral tail movements [6]. These facts indicate that cutaneous afferent inputs from one hindlimb bend the tail to the ipsilateral side. When the cutaneous receptors of skin of the hindlimb are stimulated, flexor movements of the ipsilateral hindlimb are induced. When the flexor movements occur, the gravity center of pelvic girdle would be inclined contralateral to the stimulated hindlimb as being balanced by the tail movement. The present study demonstrated that neural pathways from cutaneous afferent nerves of the hindlimb to tail motoneurons have a role to maintain the body balance, being consistent with suggestions by some previous description for quadruped with long tails [1–3].

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