Location of Motoneurons Innervating Thigh Muscles in the Cat Spinal Cord

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Many studies, using retrograde transport of horseradish peroxidase (HRP), have demonstrated the distributions and sizes of various kinds of motoneurons in the spinal cord [1, 3, 5, 9]. Some investigators have indicated that the location of motoneuron pools in the spinal cord depends on the function of the innervating muscles [7, 8]. Furthermore, it has been reported that motoneurons of the hindlimb, forelimb and neck are larger in size than those innervating the abdominal muscles [1, 3, 5]. In the present study, the author examined the localizations and sizes of five groups of motoneurons innervating obturator internus (Oi), gemellus inferior (Gi), gluteus medius (Gm), pyriformis (Py), and caudofemoralis (Cf) muscles using retrograde transport of HRP, because no systematic investigation on the motoneuron pools innervating thigh muscles has been performed.

Eight adult cats (weighing 2.8–4.2 kg) were used. Animals were anesthetized by intraperitoneal injection of sodium pentobarbiturate solution (40 mg/kg). In 5 cats, HRP (20–25%) was injected into five kinds of thigh muscles as described above (50–100 μl per muscle with multiple injections) by using a 25 μl Hamilton syringe with 26s gauge needle. To prevent HRP from leaking to other muscles, the applied muscle was separated from the surroundings without injuring the fasciae of the muscles prior to the injection and was covered with a sheet of thin vinyl film after injection. In the other 3 cats, HRP solution was applied to cut nerve ends (Gm, Gi, Cf, Py). After 48 hrs, the animals were deeply anesthetized by intraperitoneal injection of sodium pentobarbiturate solution and perfused transcardially with a) 2 l of saline, b) 3 l of fixative solution containing 1% paraformaldehyde and 1.25% glutaraldehyde in 0.1 M phosphate buffer (pH 7.4), c) 1 l of 20% sucrose-phosphate buffer (pH 7.4). The spinal cord was removed and cut into segments. The spinal segments were stored overnight in a solution of 20% sucrose in phosphate buffer at 4°C. They were identified by judging from the position of the dorsal root beginnings. Serial frozen sections were cut at 60 μm in the transverse plane from L6 to S2. HRP was visualized by the tetramethylbenzidine (TMB) method [6]. The sections were mounted on gelatin-coated glass slides and lightly counterstained with neutral red, dehydrated and coverslipped for observation. The location of labeled motoneurons and the outline of gray matter of the spinal cord were transferred onto papers with a microphotodrawing system. The number of labeled motoneurons was counted every 2nd section (i.e., 120 μm). The maximum and the minimum diameters of the labeled motoneurons with visible nuclei were measured.

Following HRP injection into individual thigh muscles, the labeled motoneurons in the spinal cord were distributed in a fashion of ipsilateral longitudinal columns to the injected muscles. Fig. 1-A shows the localization of the labeled motoneurons in the transverse section. The motoneurons of the 5 muscles were located in the ventral part of the ventral horn and the motoneuron pools were partly overlapping each other. The motoneurons innervating Cf(c) and Py(e) were located in the ventrolateral part of the ventral horn. The motoneurons innervating Gi (b) were located between two different motoneuron pools, which innervate Gm (a) and Cf (c), respectively.

Romanes [7], and Sterling and Kuypers [8] demonstrated the general distribution of motoneuron groups in the ventral horn throughout the spinal cord: the extensor motoneuron groups were located mainly medially, whereas the flexor motoneuron groups were located mainly laterally. Wada and Sugita [9] reported that the location of motoneuron pools innervating the tail muscles was related with location of tail muscles on the transverse section of the tail. The function of the 5 muscles examined in the present study was abduction of the thigh [2].
Therefore, the locations of motoneuron pools have no topographical relation to those of the muscles. Landmesser [4] showed that motoneuron position was most closely correlated with ontogenetic events in chicks. To resolve this problem, further studies will be required.

Fig. 1B shows the segmental distribution of motoneurons innervating 5 muscles. Each dot shows the number of motoneurons in 10 sections. The motoneurons innervating Gm (a), Gi (b) and Cf (c) were numerous at the rostral part of the L7 segment. The motoneurons innervating Oi (d) and Py (e) were abundant in the caudal part of the L7 segment and rostral part of the S1 segment. The segmental distribution of Oi corresponded to the result reported by Romanes [7].

Fig. 1C shows the histogram of cell body diameters (the average of the maximum and the minimum diameters of neurons with visible nuclei) by measuring HRP-labeled neurons after injection into Py. The mean diameter of motoneurons was 29 μm. Bimodal distribution was indicated, but not distinct. The motoneurons innervating the other 4 muscles were 27 to 31 μm in diameter. Bimodal distribution of the motoneurons was also observed, but not distinct. The motoneurons innervating the 5 muscles abducting the thigh were smaller in size than the hindlimb and forelimb motoneurons, but still larger than those of the abdominal muscles [1, 3, 5]. The two peaks of the histograms may correspond to alpha- and gamma-motoneuron groups as in the case of hindlimb motoneurons described by Burke et al. [1].

REFERENCES
要約

ネコの大脛の運動に関与する筋を支配する運動ニューロンの脊髄内分布（短報）：和田直己（千葉大学医学部第一生理）—大脛の運動に関与する内側鎖筋、股直筋、中殿筋、顕状筋、尾骨大脛筋を支配する運動ニューロンに関してHRP法を用いて解剖学的検討を行った。これらの筋を支配する運動ニューロンは第6腰髄後半から第1仙脛にかけて分布し、その脊髄横断面での位置は支配する筋によって異なっていた。運動ニューロンの直径は約30μmであった。