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Technique

Evoked potentials elicited on the cerebellar cortex by electrical stimulation of the rat spinocerebellar tract

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Abstract

Background: In the current study, as a first step to develop a monitoring method of cerebellar functions, we tried to record evoked potentials on the cerebellar cortex by electrical stimulation of the rat SCT, which is located in the Inf-CPed.

Methods: The experimental study was performed on rats. Unilateral muscular contractions of quadriceps femoris muscle were elicited by electrical stimulation. The evoked potentials were recorded from the surface of the ipsilateral cerebellum and the contralateral primary sensory cortex.

Results: The highly reproducible potentials obtained from the ipsilateral cerebellar hemisphere were named SCEP. The SCEP exhibited one negative peak with a latency of 11.7 ± 0.3 milliseconds (N_{11}). Short-latency somatosensory evoked potential was recorded from the contralateral primary sensory cortex with a latency of 19.1 ± 0.6 milliseconds. Coagulation of the ipsilateral Inf-CPed caused disappearance or marked reduction of the SCEP N_{11}, but it did not change the SSEP. On the other hand, sectioning of the ipsilateral dorsal column resulted in the disappearance of the SSEP, but it did not affect the SCEP N_{11}.

Conclusions: Reproducible SCEP was recorded from the rat cerebellar hemisphere by electrical stimulation of the quadriceps femoris muscle. We posit that the SCEP differs from the SSEP, which ascends via the dorsal column, and that it is conducted by the dorsal SCT located in the Inf-CPed. Our results suggest that it may be possible to detect the dysfunction of the Inf-CPed electrophysiologically by using SCEP.

Keywords: Cerebellum; Evoked potential; Inferior cerebellar peduncle; Spinocerebellar tract

1. Introduction

Various kinds of intraoperative monitoring have been used in neurosurgery. We have developed additional intraoperative monitoring techniques and applied them in patients undergoing neurosurgical procedures [11,14,17-22]. At present, however, no established methods are available for the intraoperative monitoring of cerebellar function. In the current study, as a first step to develop a monitoring method of cerebellar functions, we tried to record potentials that reflect the Inf-CPed function. We focused on the dorsal SCT, which conducts information from muscle spindles and travels to the cerebellum. The evoked potential elicited from the cerebellar surface by electrical stimulation of rat muscle spindles (SCEP) was recorded. Because the dorsal SCT passes through the Inf-CPed, we also examined the possibility of detecting Inf-CPed dysfunction by monitoring the SCEP.

Abbreviations: Inf-CPed, inferior cerebellar peduncle; Sup-CPed, superior cerebellar peduncle; SCEP, spinocerebellar evoked potential; SCT, spinocerebellar tract; SSEP, short-latency somatosensory evoked potential.

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2. Materials and methods

2.1. Animals and procedures

Experiments were performed on 52 male Wistar rats weighing 280 to 320 g. All experimental procedures complied with the guidelines on animal experiments of Fukushima Medical University, and all experimental protocols were approved by the Institutional Animal Care and Use Committee of Fukushima Medical University.

After the rats were anesthetized with 1.5% halothane in a mixture of 75% oxygen and 25% nitrous oxide, anesthesia was maintained by injecting 50 mg/kg per hour of propofol (1% Diprivan, Astra Zeneca, Inc, Osaka, Japan) into the femoral artery under spontaneous respiration. Mean arterial blood pressure was continuously monitored. Blood gases were kept in the reference range (Po_2, 90-120 mm Hg; PCO_2, 35-45 mm Hg). The body temperature was maintained at 37°C to 38°C with a warming blanket and monitored rectally. During the operation, the rats were in prone position. The ipsilateral hind limb was placed in a natural position to avoid limiting muscle contractions.

2.2. Spinocerebellar evoked potential recordings

After exposing the quadriceps femoris muscle unilaterally, 2 stimulation needle electrodes (45386, GE Market Medical System, Tokyo, Japan) were inserted 10 mm apart and along the axis of the muscle fibers. The muscle was electrically stimulated at 2 Hz with a 200-millisecond rectangular wave pulse using an electric stimulator (DPS-1100D, Dia Medical System, Tokyo, Japan) and an isolator (5384, NEC SAN-ei Instruments Corp, Tokyo, Japan).

After suboccipital craniectomy, both cerebellar hemispheres were exposed widely. A silver ball electrode, approximately 1 mm in diameter (45182, GE Market Medical System), was placed as a recording electrode on the posterior lobe of the cerebellum (Fig. 1). The reference electrode was a silver ball electrode inserted subcutaneously in the ipsilateral auricula. Spinocerebellar evoked potential was recorded through a band-pass filter set for 80 to 3000 Hz, and 150 responses were averaged using a signal processor (Synax1100, NEC Co Ltd, Tokyo, Japan).

Spinocerebellar evoked potential was analyzed for the following: (1) specificity of the recording site, (2) the effects of electrical stimulation artifacts, (3) the effect of electrical stimulation intensity increase, and (4) the effects of muscle relaxant administration on SCEP amplitude.

2.3. Short-latency somatosensory evoked potential recordings

The same electrical stimulation series and characteristics were used for SSEP as for the SCEP, but the stimulus intensity was 3 mA. After exposing the contralateral parietal lobe, a recording silver ball electrode was placed on the hind leg area [7,15,16] of the primary sensory cortex. The reference electrode was a silver ball electrode introduced into the ipsilateral auricula.

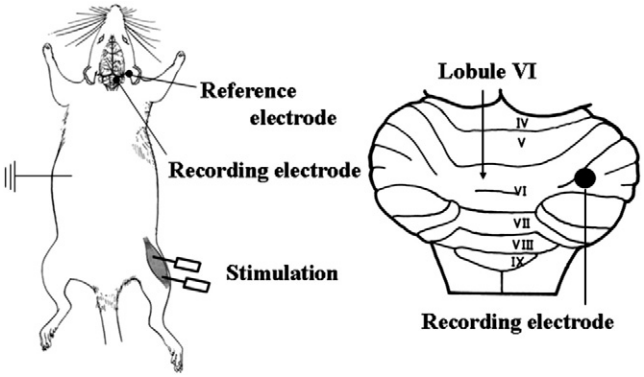

Fig. 1. Schematic representation of SCEP recording (left) and dorsal view of the cerebellum (right). The unilateral quadriceps femoris muscle was electrically stimulated. The recording electrode was fixed 3 mm lateral from the midline of the ipsilateral cerebellar lobule.

2.4. Changes in SCEP and SSEP as a result of destruction of the conduction pathways

To be able to track the conduction pathways of the SCEP, the ipsilateral dorsal column was sectioned in 4 rats and the ipsilateral Inf-CPed was electrically coagulated in 8 rats. Because of the possible contribution of the contralateral ventral SCT in the conduction of the SCEP via the contralateral Sup-CPed to the ipsilateral cerebellar hemisphere, the contralateral Sup-CPed was coagulated in 4 rats [15,16]. Changes in SCEP and SSEP were examined before and after destruction of these conduction pathways. Sectioning of the ipsilateral dorsal column was done with a sharp knife at the level of the foramen magnum. For electric coagulation of the ipsilateral Inf-CPed or the contralateral Sup-CPed, we applied a bipolar needle coagulator with a 1.5-mm tip attached to an endoscope (HZ-1005B, Machida Corp, Tokyo, Japan). The needle was inserted stereotactically from the cerebellar surface with a micromanipulator (SR-5, Narishige Corp, Tokyo, Japan).

To coagulate the ipsilateral Inf-CPed, the needle electrode was inserted from the cerebellar surface (15 mm caudal from the bregma and 3-4 mm lateral from the midline) to the target (9 mm caudal and 7 mm ventral from the bregma and 3-4 mm lateral from the midline) [15,16]. For electrical coagulation of the contralateral Sup-CPed, the needle was inserted from a point (15 mm caudal from the bregma and 2-3 mm lateral from the midline) to the target (9 mm caudal and 5 mm ventral from the bregma and 2-4 mm lateral from the midline) [15,16]. Each coagulation was performed with 30 W for 3 seconds.

After these experiments, the rats were sacrificed; their brains were fixed in 10% formalin, and the lesions were histologically confirmed for location and size.