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Spindle-like activity appearing during paradoxical sleep in rats with iron-induced cortical focus.

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Abstract

Under barbiturate anesthesia, male Wistar rats weighing 250-300 g were injected with 2.5 microliters of 0.2 M FeCl3 solution into the left sensori-motor cortex to induce an epileptic focus with minimal abnormal activities. Polygraphy started 1 week after the surgery, showed a spindle-like hypersynchronous activity that appeared not only in the slow wave sleep period but also during paradoxical sleep (PS). This activity had a frequency of 8-14 Hz. The amplitude was more than 200 mu v in the right (non-injected side) cortex but very small in the left cortex (injected side). Isolated spike discharges were observed in an ECoG of slow wave sleep. Apart from this activity there was nothing resembling the usual sleep spindles.

KEYWORDS: iron-induced focus, paradoxical sleep, spindle-like activity

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— BRIEF NOTE —

SPINDLE-LIKE ACTIVITY APPEARING DURING PARADOXICAL SLEEP IN RATS WITH IRON-INDUCED CORTICAL FOCUS

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Abstract. Under barbiturate anesthesia, male Wistar rats weighing 250-300 g were injected with 2.5 μl of 0.2 M $FeCl_3$ solution into the left sensori-motor cortex to induce an epileptic focus with minimal abnormal activities. Polygraphy started 1 week after the surgery, showed a spindle-like hypersynchronous activity that appeared not only in the slow wave sleep period but also during paradoxical sleep (PS). This activity had a frequency of 8-14 Hz. The amplitude was more than 200 μv in the right (non-injected side) cortex but very small in the left cortex (injected side). Isolated spike discharges were observed in an ECoG of slow wave sleep. Apart from this activity there was nothing resembling the usual sleep spindles.

Key words : iron-induced focus, paradoxical sleep, spindle-like activity.

An iron-induced focus was developed as a model of a traumatic epileptic focus (1). We regard this focus as the model of a plastic change of the brain and succeeded in inducing a focus with minimal abnormal activities. In the present paper, we report a spindle-like hypersynchronous activity which was found in the ECoG of animals with such a focus and which was characterized by appearing not only in slow wave sleep stage but also in the PS stage. There has been no report so far on spindle-like activity appearing in the PS stage of rats with such an iron-induced focus, although some reports exist on similar activity in a microencephalic rats (3, 4).

Materials and methods. As the experimental material, male Wistar rats weighing 250-300 g were used. Under thyamylal sodium anesthesia (50 mg/kg), rats were mounted on a stereotaxic apparatus. For rats in the experimental group, 2.5 μl of 0.2 M $FeCl_3$ solution was injected with a microsyringe into the left sensorimotor cortex at the motor representation for the contralateral forelimb (3 mm lateral and 1 mm rostral to the bregma). The injection took ca 15 min. For animals of the control group, 2.5 μl of saline was injected into the left sensorimotor cortex by the same method as for the experimental group. At the same time, electrodes for recording of the EEG, ocular mechanogram and EMG of neck muscles were implanted. Electrodes for EEG were implanted bilaterally into the cranial bone over the frontal and the parieto-occipital cortical areas and also into the hippocampus. An indifferent electrode was implanted into the nasal bone. One week after surgery, polygraphic recording was begun for 12 h from 7 a.m. to 7 p.m. During this polygraphy, animal behavior was carefully observed.

Results. One week after surgery, rats of the experimental group showed no sign of clinical seizure or of poly-spikes in the ECoG. There were only isolated spikes in the ECoG during slow wave sleep (Fig. 1A). As the most peculiar finding, spindle burst-like hypersynchronous activities appeared repetitively in the ECoG of experimental rats during the PS period (Fig. 1B, Fig. 2). The latter period was identified unmistakeably by polygram; that is, desynchronization of the ECoG, hypersynchronization of hippocampal theta activities, appearance of rapid eye movements and disappearance of EMG of neck muscles all occurred (Fig. 1B, Fig. 2). The spindle-like activity was outstanding in the ECoG of the noninjected side (right) of the cortex. On the other hand, its amplitude was often very small on the injected side (left) of the cortex. The spindle-like activity that appeared in the right cortex had a frequency of 8-14 Hz and an amplitude of more than 200 μV (Fig. 1, Fig. 2). This activity also appeared during the slow wave sleep period but its amplitude was greater in the PS. The shape of this activity was similar to the hypersynchronous spindle waves which usually

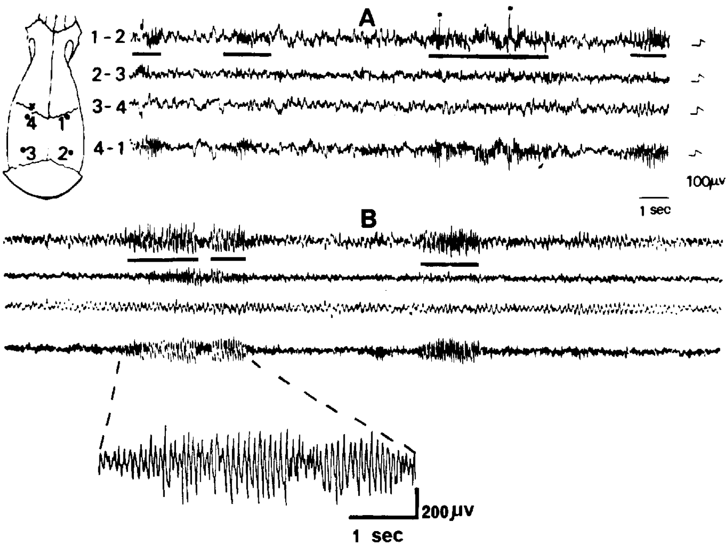

Fig. 1. Single spike activity (■) and spindle-like activity of 14 Hz (underlined) seen in the ECoG of a $FeCl_3$-injected rat.
A: Slow wave sleep. B: Paradoxical sleep. 4, 1: Left and right frontal. 3, 2: Left and right occipital. X: The place of injection of $FeCl_3$ solution.

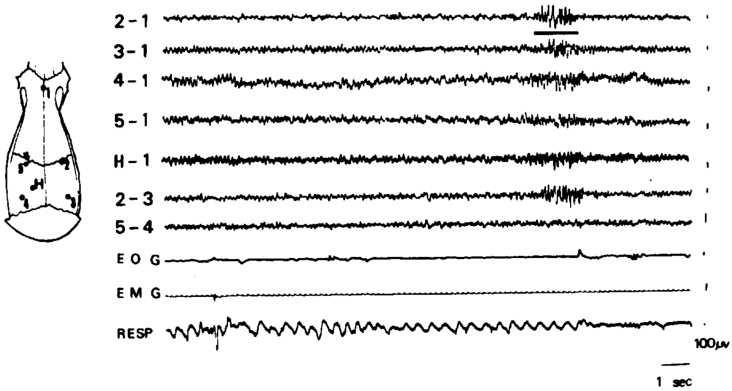

Fig. 2. A polygraphic record of paradoxical sleep in another $FeCl_3$-injected rat. Spindle-like activity of 8 Hz ((underlined) is seen.
1: Indifferent electrode. 5, 2: Left and right frontal. 4, 3: Left and right occipital. X: The place of injection of $FeCl_3$ solution. EOG: Electrooculogram. EMG: Electromyogram from the neck muscle. Resp: Respiratory movements.

appear in transient periods from slow wave sleep into PS of normal rats. Assuming that these two activities were the same, the average appearance rate per minute for total PS period during the 12 h from 7 a.m. to 7 p.m. was calculated for the experimental and the control groups. It was 0.72 ± 0.43/min (N = 4) in the experimental group and 0.11 ± 0.14/min (N = 4) in the control group. The value was significantly higher in the experimental group ($P < 0.05$, t-test). Except for this activity, there was no other activity which had a wave-form and spatio-temporal distribution resembling the sleep spindle.

Discussion. Moriwake *et al.* (2) reported on the forebrain spindle in cats and on its relation to amygdaloid kindling. According to their report, this activity was distributed over the areas that contain high concentrations of dopamine. This spindle had a frequency of ca 40 Hz and appeared only in the arousal state. It exaltated by kinding procedures. Sano *et al.* (3) and Kiyono *et al.* (4) reported the appearance of a spindle in the PS period in microencephalic rats induced by methylazoxymethanol acetate (MAM). Our spindle-like activity differed from the forebrain spindle reported by Moriwake *et al.* because of the difference in frequency and temporal distribution. The PS-spindle in MAM microencephalic rats reported by Sano *et al.* or Kiyono *et al.* might be the same as ours because of its similar frequency and temporal distribution. It is not clear whether there are differences in spatial distribution between these two activities although the spindle-like activity reported in the present paper had a greater amplitude in the contralateral cortex as far as we observed. The PS-spindle in the MAM-treated rats may be related to the atrophy of their cerebral cortex.

On the other hand, extensive atrophy of the cerebral cortex has not been found in rats with an iron-induced epileptic focus (1, 5). We consider that in our epileptic rats, the last spindle which appears during the transient period from slow wave sleep into PS might keep appearing throughout the PS period. Usually, the spindle which appears during the transient period has a larger amplitude than that of the usual sleep spindles which appear in the slow wave sleep period. The amplitude of the spindle-like activity in the present report was as large as that of the last spindle appearing in the transient period.

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