

Acta Medica Okayama

Volume 37, Issue 5

1983

Article 9

OCTOBER 1983

Deviation of somatosensory evoked potential and lateral dominance of spike activity in iron-induced epileptic cortex of the rat.

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Abstract

A chronic epileptic focus was induced by a microinjection of ferric chloride solution into the sensorimotor cortex of rats. Two types of somatosensory evoked potentials (SEPs) were recorded from the cortex near the injection site. In animals showing an initial positive-negative biphasic SEP, spikes appeared in electrocorticograms (ECoGs) more frequently on the side ipsilateral to the injection site than on the contralateral side, whereas in animals showing an initial negative monophasic SEP, spikes appeared more frequently on the contralateral side.

KEYWORDS: rat cerebral cortex, iron-induced epileptic foci, somatosensory evoked potential, electrographic discharge

*PMID: 6650225 [PubMed - indexed for MEDLINE]

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Acta Med. Okayama 37, (5), 447-450 (1983)

— BRIEF NOTE —

**DEVIATION OF SOMATOSENSORY EVOKED POTENTIAL
AND LATERAL DOMINANCE OF SPIKE ACTIVITY IN
IRON-INDUCED EPILEPTIC CORTEX
OF THE RAT**

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Received April 26, 1983

Abstract. A chronic epileptic focus was induced by a microinjection of ferric chloride solution into the sensorimotor cortex of rats. Two types of somatosensory evoked potentials (SEPs) were recorded from the cortex near the injection site. In animals showing an initial positive-negative biphasic SEP, spikes appeared in electrocorticograms (ECoGs) more frequently on the side ipsilateral to the injection site than on the contralateral side, whereas in animals showing an initial negative monophasic SEP, spikes appeared more frequently on the contralateral side.

Key words : rat cerebral cortex, iron-induced epileptic focus, somatosensory evoked potential, electrographic discharge.

Several authors (1, 2) have reported on deviations of the somatosensory evoked potential (SEP), for instance, changes in peak latency or amplitude of SEP components, related to the development of a cortical epileptic focus. Recently, we found that in iron-induced epileptic foci the deviation of SEPs was not exceptional : SEPs with only an initial negative monophasic deflection were often recorded near the primary focus (3). As the first step in the clarification of the cause of such abnormal SEPs, an attempt was made to relate their appearance to certain features of spike activity in electrocorticograms (ECoGs) which are thought to be the most fundamental indication of the epileptic state.

The cortical spike activity of iron-induced foci is not always more frequent on the side ipsilateral to the injection site than on the contralateral side. Therefore, the present study was designed to determine under what conditions the appearance of abnormal monophasic SEPs occur near the primary focus in relation to which side of the cortex is dominant in ECoG spike activity.

Materials and methods. A microinjection of ferric chloride solution to induce an epileptic focus was performed employing the method of Willmore *et al.* (4, 5). Through a trephine hole, 5 μ l of 0.1 M FeCl₃ solution was injected into the left frontal cortex of male Wistar rats (230-280 g). The injection site was 1.5 mm

rostral and 3.5 mm lateral to the bregma corresponding to the motor representation for the contralateral forelimb (6). After the injection, stainless steel electrodes for SEP and ECoG recordings were implanted bilaterally in the cranial bone.

Unless otherwise noted, ECoGs and SEPs were recorded 30 to 60 days after the injection. ECoG recordings used to determine the side of dominant cortical spike activity were made continuously for more than three hours with the rats unrestrained. Then, SEPs of the same animals were evoked and recorded on the same day as the ECoG recordings according to the method of Angel *et al.* (7). Under thiamylal sodium anesthesia (50 mg/kg, i.p.), the forelimb contralateral to the cortical injection site was stimulated (2-4 V, 1 msec, 1/sec) and the SEP was monopolarly recorded from the cortical electrodes at a point 3.5 mm lateral to the bregma. Fifty consecutive SEPs were averaged. To determine the type of SEP of an animal, the recording of averaged SEPs was repeated several times in that animal.

Results and discussion. SEPs recorded from the cortex near the injection site 30 to 60 days after the injection of ferric chloride solution were classified into two types according to their configurations as reported previously (3). The first type had an initial positive-negative deflection and was characterized by a rather small initial positive deflection and early transition to the negative phase. The second type had only an initial negative deflection devoid of the positive phase. Monophasic SEPs were observed in 57 % of the animals, while biphasic SEPs were observed in 35 % ($n = 23$, data not shown). The percentage was not different when the averaged SEPs were recorded from the same animals at an earlier time, *i.e.*, 13 to 15 days after the injection. Each animal showed the same type of SEP through the different experimental stages.

As shown in Table 1, spikes were manifested in three ways in ECoGs. In the first type, unilaterally isolated spikes were seen only on the side of the primary focus, and in the second they were seen only on the side of the secondary focus. In the third type, spikes appeared bilaterally almost simultaneously on both sides. All three types of spike appearance were observed in each animal. Table 1 clearly

TABLE 1. CONFIGURATION OF SEPs AND THE SIDE OF SPIKE APPEARANCE IN THE EPILEPTIC CORTEX

Type of SEP	Spike appearance (%)		
	Ipsilateral	Contralateral	Bilateral
Biphasic	28 ± 3	17 ± 3	55 ± 4
Monophasic	14 ± 2	36 ± 4	50 ± 4

ECoG and SEP recordings were performed in rats 30 to 60 days after an injection of FeCl₃ solution. Isolated spikes in ECoGs appeared ipsilaterally or contralaterally of the injection site or bilaterally. Each value represents the mean \pm S.E.M. of the percentage of spike appearance of eight different animals. In the biphasic SEP group, the mean number of spikes was 49/h, while in the monophasic SEP group it was 58/h.

shows that in animals having biphasic SEPs, spike appearance was more frequent on the side ipsilateral to the injection site than on the contralateral side, and that in animals having abnormal monophasic SEPs, it was more frequent on the contralateral side than on the ipsilateral side.

Recently, Reid and Sybert (8) found by unitary analysis that characteristic high frequency burst discharges were observed much more frequently from the iron-induced focus than from the surround. They also showed that in the surround, many unit discharges were inhibited as surface ECoG spikes occurred. These findings suggest that reorganization of neuronal activities occurred around the epileptic focus due to the appearance of the latter.

Majkowski and Kwast (2) reported on the deviation of SEPs and the development of the epileptic state in a case of cortical kindling. Takahashi and Straschill (1) reported on the configurational change in SEPs appearing after the induction of a penicillin focus. In the former study, the deviation of SEPs appeared in the late components. Further, Majkowski and Kwast (2) reported that the deviation of SEPs seems to represent a nonepileptic process because the deviation occurred bilaterally and preceded the appearance of spike discharges.

In the present experiments, neither was the configuration of the later component of SEPs analyzed, nor was a simultaneous recording of SEPs and ECoGs made. Therefore, nothing can be said as to whether or not the nature of the observed deviation of SEPs was epileptic, or as to what temporal relation exists between components of SEPs and surface ECoG spikes. The appearance of negative monophasic SEPs near the primary focus in the present experiments, however, strongly suggests that evoked neuronal activities were reorganized around the epileptic focus by its appearance.

Though unitary analysis of the iron-induced focus was not performed, there was a consistent relationship between the deviant SEPs and ECoG spikes, namely, initial negative monophasic SEPs were observed in animals in which unilateral spike discharges were more frequent on the contralateral side of the cortex. It is presumed, therefore, that the unilateral ECoG spike activity may be a reflection of the change in intracortical functional organization which is expressed as deviant SEPs. As to the biphasic type of SEPs of the epileptic cortex, it seems difficult at the present time to decide whether or not this type is really abnormal.

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