Evaluation of Source Generators in Partial Seizures — Availability of Neuroradiological Images Superimposed on the Dipole Tracing —

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ABSTRACT. To clarify the anatomical localization of epileptic foci in childhood partial seizures, the source generators of interictal focal spikes were analyzed using a dipole tracing method and the effectiveness of a composite image diagnostic technique using neuroradiological images obtained by magnetic resonance imaging and single photon emission computed tomography was evaluated. The localization of electric source generators approximately reflects the abnormal lesions on neuroradiological images. However, the source generators tended to be located in the deep and/or peripheral parts of the abnormal regions. Even though systemic shifts in the position of optimal dipoles from their true positions is a limitation that must be taken into consideration, composite image diagnostic technique may be useful for evaluating the epileptogenic regions in partial seizures, and particularly, in children where noninvasive methods are preferable.

Key words : dipole tracing method — source generators in partial seizures

Evaluating the localization of epileptic foci is necessary for both the diagnosis and management of epilepsies. Recent advances in a epileptic surgery and a depth recording using stereotaxic procedures have been widely accepted for use with adult epileptic patients, but these methods may be too invasive for use with children. Dipole tracing (DT) is a noninvasive method for estimating the localization and vector moment of electric source generators as equivalent dipoles based on the distribution of electric potentials over the scalp.[1,2,3] There have been few reports regarding the efficacy of this new method for various kinds of evoked potentials and childhood epilepsy.[1,4] However, it is difficult to assess the anatomical localization of epileptic foci in detail. Previously, the authors investigated and on the anatomical localization of periodic synchronous discharges of subacute sclerosing panencephalitis using neuroradiological images superimposed on DT and proposed that it could be useful composite image diagnostic technique. This study was carried out to clarify the anatomical localization of epileptic foci in partial seizures using neuroradiological images superimposed on DT images.

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SUBJECTS

Three cases of localization-related epilepsy in children were analyzed. Their clinical courses were as follows: Case 1 was a four-year-old Japanese girl referred to us because of focal motor seizures of the right limbs which sometimes became generalized during a two year period. Waking interictal electroencephalograms (EEG) showed focal spikes, spike and waves in the left parietal ~ central area. Ictal EEG foci also originated from this area. Neuroradiologically, both magnetic resonance imaging (MRI) and cranial computed tomography (CT) revealed cortical atrophy in the area adjacent to the midtemporal lobe. ^{99m}Tc hexamethyl-propylene-amineoxime (^{99m}Tc HM-PAO) single photon emission computed tomography (SPECT) disclosed decreased regional cerebral blood flow (rCBF) in the temporal lobe.

Case 2 was a seven-year-old Japanese boy with occipital lobe seizures. He was born after 39 weeks gestaton with a birth weight of 1850 g. Although he experienced convulsions due to hypoxic ischemic encephalopathy during the neonatal period, his psychomotor development has been normal. Between nine months and two years of age, febrile convulsions occurred. Since two and a half years of age, he has suffered from adversive seizures of both the head and eyes which deviated toward the left side. His waking interictal EEG showed focal spikes in the right occipital area and ictal EEG foci also originated from this area. MRI disclosed abnormal signal intensity of dysmyelination in the area of optic radiation. However, no definite abnormal lesion was seen on his cranial CT. ^{123}I-isopropyl-p-iodoamphetamine (^{123}I-IMP) SPECT indicated decreased rCBF of the right occipital ~ postero-temporal area.

Case 3 was a ten-year-old Japanese boy with frontal lobe seizures. He is mentally retarded with a development quotient of 50 and suffers from right hemiplegia. Afebrile convulsive seizures first occurred at two years of age. These were followed by complex partial seizures with a left frontal mesial focus. The clinical feature of these partial seizures was a motionless stare that evolved to pseudoabsence. His waking interictal EEG showed focal spikes in the left frontal ~ frontal mesial area which sometime propagated to adjacent areas. Ictal EEG foci originated from same area. Both CT and MRI findings indicated slight cortical atrophy of the bilateral hemispheres. However, ^{123}I-IMP SPECT disclosed increased rCBF in the frontal mesial area.

METHODS

EEGs were performed with 21 electrodes on the scalp (16 active electrodes according to the international 10-20 system) with an ear reference on the ear opposite the spike localization. Focal spikes were also recorded on a data recorder during the interictal waking state, and an NEC-Sanei signal processor 7T18 was used for analyses. The location and vector moments of the electric source generators were analyzed using DT program No. 200 (Homma *et al.* 1987).[2] The NEC-Sanei 711A topography system was used to evaluate the distribution of spike potentials. The dipoles were estimated from 10-20 points including the peak of the spikes. Composite images were made by a computer (IBAS, Interaktives Bild Analysen System) using a megaplus zoom camera. An anatomical localization of the epileptic foci was estimated by superimposing DT images on both MRI and SPECT images.

RESULTS

Case 1 : The electric source generators were located in the area adjacent to the deep central part and/or medial part of the temporal lobe. The dipolarity (the validity of the dipole approximation) was more than 97%. The peak spike was also located in the left central area, which corresponds to the C3 electrode on dynamic topography. As shown in Fig. 1., composite images of DT superimposed on dynamic topography showed the location of source generators on dynamic topography. Composite images with DT, SPECT and MRI are

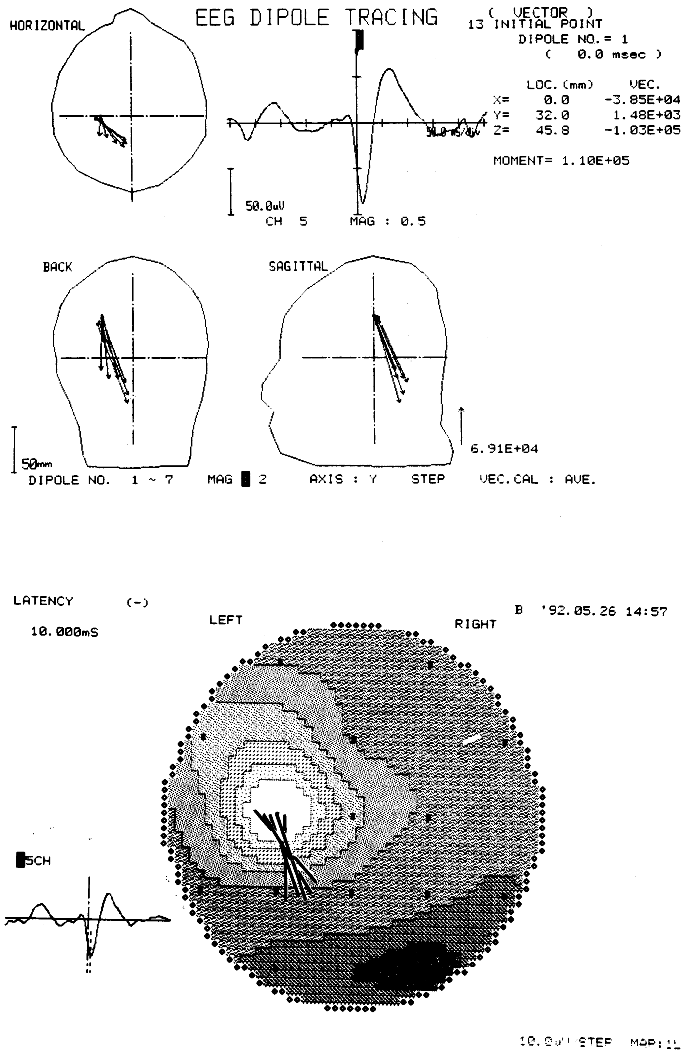

Fig. 1. Top indicated the source generators of focal spike and bottom showed DT superimposed on dynamic topography.

shown in Fig. 2. Based on these images, the dipoles were determined to be approximately located in the area adjacent to the anatomically abnormal regions whereas the source generators tended located in the deep part of the abnormal regions.

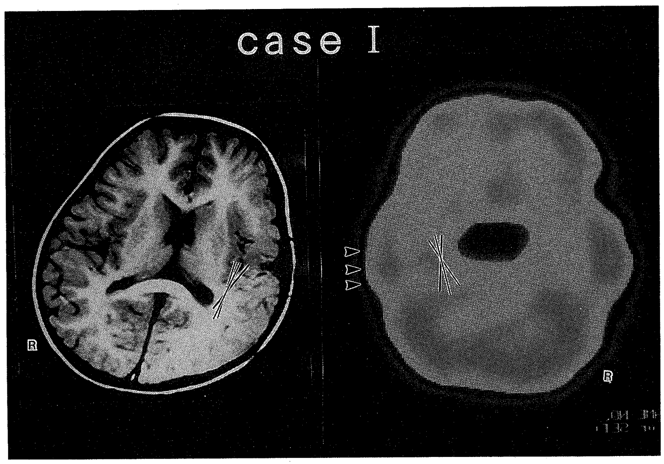

Fig. 2. DT superimposed on SPECT and MRI.

Case 2: The electric source generators were located in the right posterior area, and dipolarity was more than 97%. The central part of the peak spike was located in an area adjacent to the P4 electrode on dynamic topography. As shown in Fig. 3, dipoles were located in the peripheral part of a right parietal lesion on composite images of DT superimposed on dynamic topography. Composite images with DT, SPECT and MRI are in shown Fig. 4. Based on these images, the dipoles were considered to be approximately located in the region of abnormal signal intensity and in the area of decreased rCBF on neuroradiological images

Case 3: The electrical source generators were located in the deep part of the left frontal mesial area. Composite images with DT and SPECT indicated the dipoles were localized toward the peripheral area of increased rCBF in the left frontal mesial area (Fig. 5).

DISCUSSION

The dipole tracing methods are based on a realistic head model having uniform electrical conductivity.[2,3] However, there are certain problems involved in estimating the accuracy of source generators analyzed by the DT methods.

Homma and Musha noted two difficulties inherent in this method. Firstly, the low electrical conductivity of the skull causes systematic shifts of the optimal dipole positions from the true position of concentrated sources. Secondly, the optimal dipoles cannot specify diffuse source positions. Therefore, they proposed that the optimal dipole must have been 98%.[3] Recently, the DT methods have been used to evaluate the source generators of

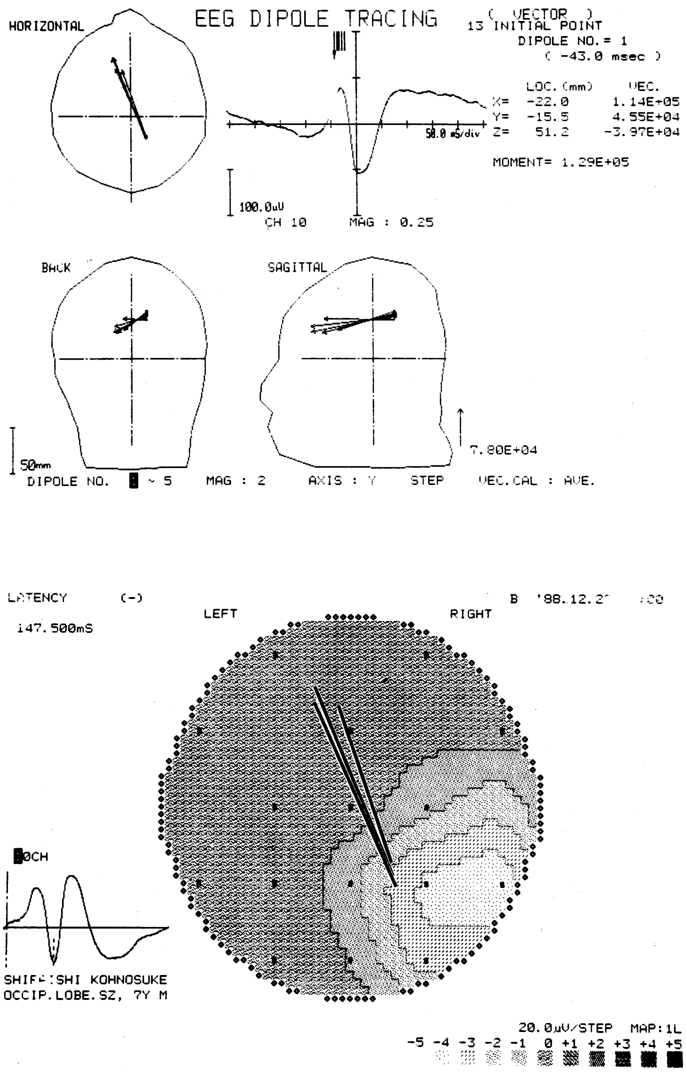

Fig. 3. Top indicated the source generators of focal spike and bottom showed DT superimposed on dynamic topography.

epileptic foci and other paroxysmal discharges.[1,4] Yoshinaga *et al.*[5] reported detection of benign childhood epilepsy with centrotemporal spikes (BECS) using DT and noted that compared with other types of partial seizures, spikes of the BECS were characterized by constantly stable dipoles. Furthermore, the dipoles were located strictly in the Rolandic area. They also proposed that DT methods may be useful for elucidation of the pathophysiology of childhood epilepsy.

The anatomical localization of dipoles approximately reflects the parts of

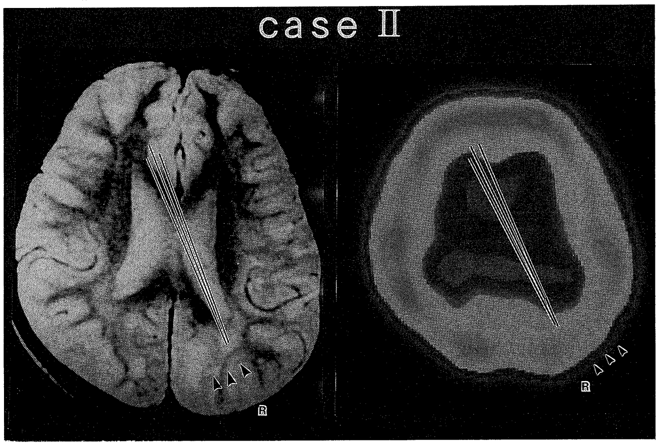

Fig. 4. DT superimposed on SPECT and MRI.

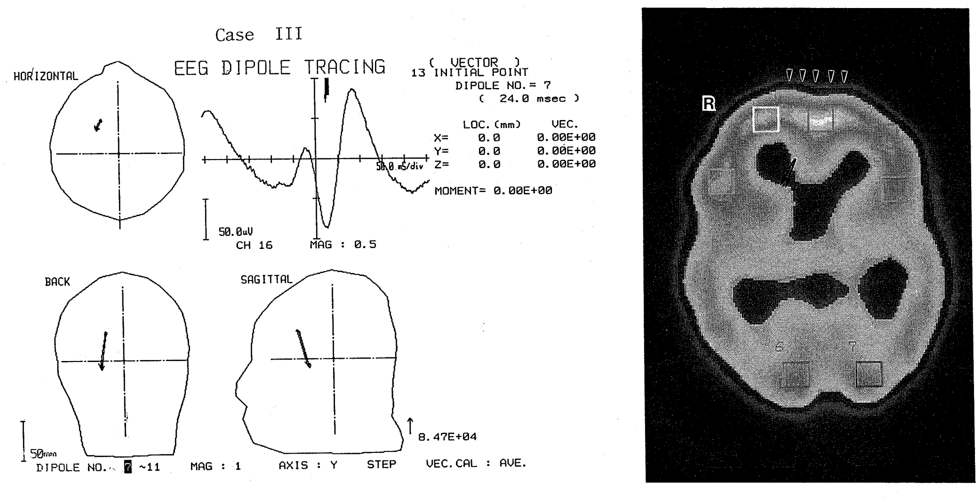

Fig. 5. The source generators of focal spike and DT superimposed on SPECT (arrow heads indicated increased cerebral blood flow of bilateral frontal mesial).

the neuroradiologically abnormal lesion. It should be realized, however, that there are systemic shifts in the positions of the optimal dipoles from their true positions. Even with this limitation, however, composite image diagnostic techniques, such as the one introduced here, can be useful for evaluating the anatomical localization of partial seizures in childhood.

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