Case Report

The First Invasive EEG Monitoring for Surgical Treatment of Epilepsy in Thailand

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The authors report the first invasive electroencephalography (EEG) monitoring in Thailand in a patient who had intractable left temporal lobe epilepsy. The seizure origin and functioning cortices were identified. The corresponding epileptogenic zone was resected without functional deficit. The patient has become seizure free 1 year since surgery.

Subdural EEG monitoring with cortical stimulation have been developed at this tertiary epilepsy center. The technique provides essential evidence for the surgical decision so that the best post operative outcome can be achieved.

Keywords: *Cortical stimulation, Epilepsy, Epilepsy surgery, Invasive monitoring, Subdural electrode, Gamma knife radiosurgery*

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Epilepsy surgery is now the standard treatment of drug-resistant epilepsy. The morbidity and mortality of epilepsy surgery are low[1]. The advent of modern neuroimagings especially magnetic resonance imaging (MRI), preoperative epilepsy surgery evaluation is able to localize the epileptogenic zone better than before. However, in at least 25% of adult patients in epilepsy surgery centers, the noninvasive presurgical data can not precisely localize the epileptogenic zone[2]. In these patients, intracranial EEG plays a role in delineating the resectable epileptogenic origin thus providing the opportunity for the patients of the best possible surgical outcome. The authors report here the first use of subdural electrodes for video/EEG recording and functional stimulation mapping in Thailand for surgical treatment of intractable temporal lobe epilepsy.

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Case Report

A 31-year old, right handed female had her epilepsy onset at the age of 12. She reported 3 seizure types namely aura only, complex partial seizure (CPS) with vocalization, right facial clonic or right arm tonic seizures and CPS with secondarily generalized tonic-clonic seizures (GTC). She had been treated with many antiepileptic medications but her seizures could not be controlled. She underwent gamma knife radiosurgery at the left temporal lobe for her epilepsy at a private hospital in 1997. The information regarding preoperative EEG and MRI were not available for review. Her seizures were improved for a few months and then recurred to the pretreatment frequency.

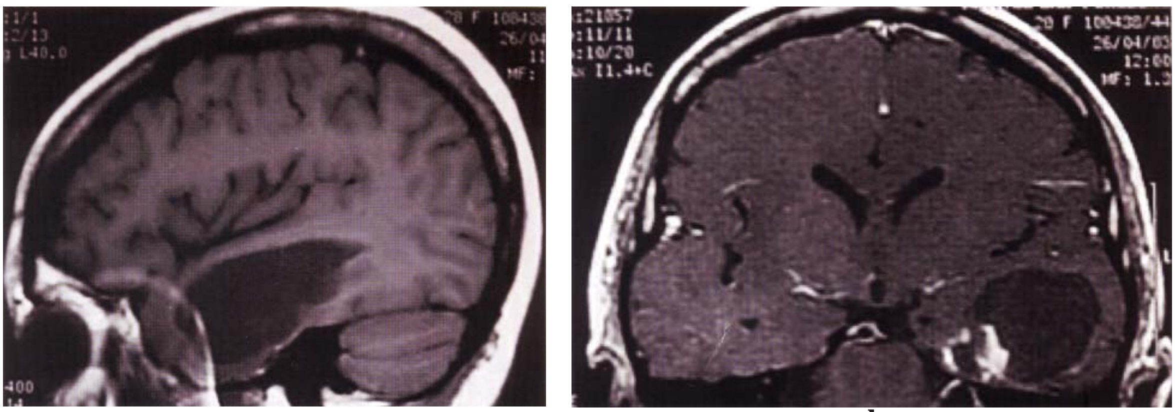
The patient came to Chulalongkorn Comprehensive Epilepsy Program (CCEP) for evaluation of her intractable epilepsy in 2002. Her routine EEG showed rare interictal epileptiform discharges (IEDs) over the left fronto-temporal region (F7, FT9) and her MRI showed post-radiosurgical cystic necrosis of the left temporal lobe with a small medial enhanced nodule. The hippocampus head and body were intact but upward displaced from the cystic lesion (Fig. 1).

Antiepileptic medications had been adjusted but her seizures remained unchanged. She was therefore admitted for 24-hour EEG monitoring on October 4-15, 2002. Interictal EEG showed left frontotemporal discharges and ictal EEG showed left hemispheric lateralization but unclear localization. Her ictal SPECT revealed hyperperfusion at the left hemisphere including basal ganglion, thalamus, and temporo-parietal regions with markedly decreased uptake at left anterior to mid temporal region corresponding with the cystic MRI lesion (Figure 2a). A MIBI scan showed increased uptake at her right medial temporal lobe, suggesting a viable nidus rather than a scar tissue (Fig. 2b).All these noninvasive presurgical tests suggested left temporal epileptogenic zone but the extent of safe resection from her speech areas could not be determined.

The authors decided to perform invasive EEG monitoring in order to identify the seizure onset zone as well as the adjacent eloquent cortices. The patient underwent craniotomy for subdural electrode (SDE) placement on November 15, 2004. She was under general anesthesia. Four subdural grid electrodes (Ad-tech, Wisconsin, USA), one of 8 x 8, one of 2 x 8 and two of 1 x 6 contacts, were placed to cover the left inferior frontal, lateral temporal, parieto-occipital and basal temporal areas (Fig. 3).

The invasive monitoring was recorded 24-hours a day for 3 days using a 128-channel digital video-EEG analogue. The ictal EEG onset was consistently found to originate from a single basal anterior temporal contact (B2) in all episodes, 3 of which also simultaneously appeared at a superior frontal contact (A3). The invasive monitoring could clearly point out the ictal origin compared to the previous scalp monitoring which showed only late left hemispheric propagation. The IEDs were 60% recorded over the left superior fronto-parietal region (upper A plate) and minimally over wide surrounding areas (Fig. 4).

After the authors obtained enough information of her seizures, the authors performed cortical stimulation mapping through the grid electrodes in order to identify the functioning areas. The authors used Ojemann Cortical Stimulator (OCS-1) with alternate polarity, 50 Hz frequency, 200 sec pulsewidth current. The electrical intensities were gradually increased to the maximum of 10 mA or until the patient's clinical responses were observed. Afterdischarges (Ads) were monitored as well as the patient's auras and seizures. All 92 contacts of 4 SDE were stimulated and the identified functioning areas were mapped (Fig. 5). Later, the somatosensory evoked potential (SSEP) was also recorded to locate the central sulcus. The authors could thoroughly identify the motor, sensory, speech and visual areas from the SDE stimulation (see diagram). The ictal onset zone was concluded to be at the left



a b

Fig. 1 Preoperative MRI of the patient showing area of cystic radiosurgical necrosis at the left anterior and middle temporal lobe. a) T1 WI sagittal view. Artifact from metal denture was also noted. b) Coronal T1 WI with Gadolinium showing an enhanced medial nodule with intact but displaced left hippocampus

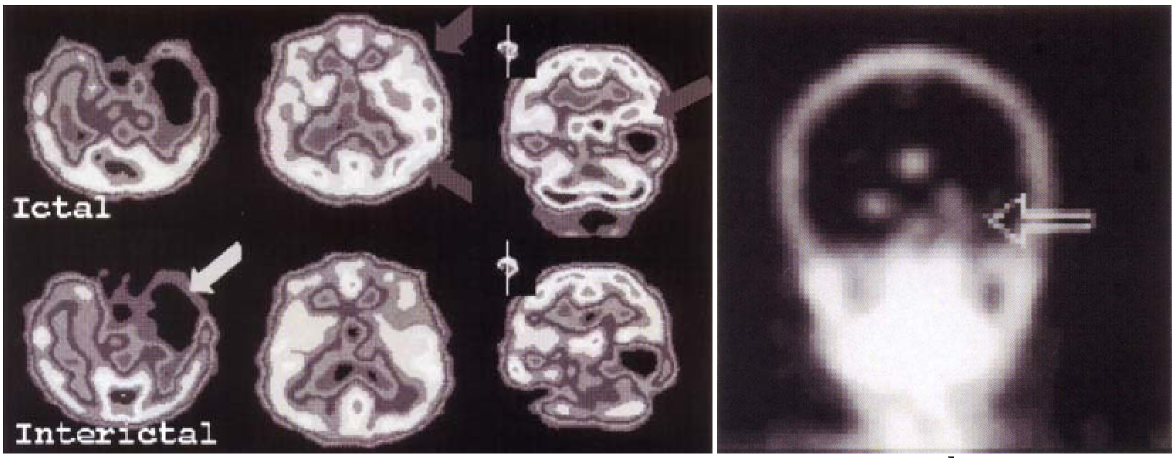


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Fig. 2 a) Ictal SPECT scan showing regional hyperperfusion at left parieto temporal lobe, left basal ganglion, and thalamus compared to the interictal SPECT which showed markedly decreased uptake at left anterior to mid temporal region corresponding with the cystic lesion. b) MIBI brain scan showing right mesial temporal area with increased uptake

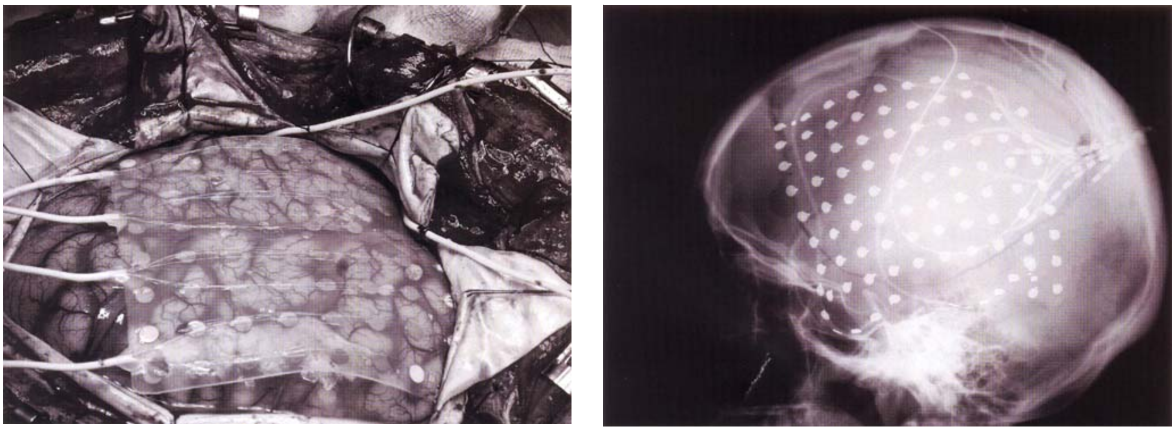

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Fig. 3 a) A subdural grid electrode placed over the patient's left fronto-temporo-parietal surface. b) Four subdural electrodes seen under skull x-ray

inferior anterior temporal surface. The resection line could therefore be proposed from which the ictal onset zone and the lesion were removed and the eloquent speech areas preserved.

She underwent recraniotomy on November 25, 2004. The area of resection and speech areas were reoriented from the subdural electrodes and marked. The grid electrodes were explanted and left temporal lobectomy with amygdalo-hippocampectomy was performed along the proposed resection line (Fig. 6).

Post operatively, she had no neurological deficit except transient diplopia and a well compensated right hemifield visual impairment. All her seizures and auras have completely disappeared and she has remained seizure free for 1 year since surgery (Engel I)[1]. Pathological examination showed radiation effect and a cavernous angioma (Fig. 7).

Discussion

The authors reported the first invasive EEG monitoring and stimulation mapping in Thailand. The procedure plays important role in localizing the epileptogenic zone as well as in defining the functioning areas. Without subdural electrode implanted, the localization of ictal onset and the eloquent areas would not be possible in this case. The post operative result

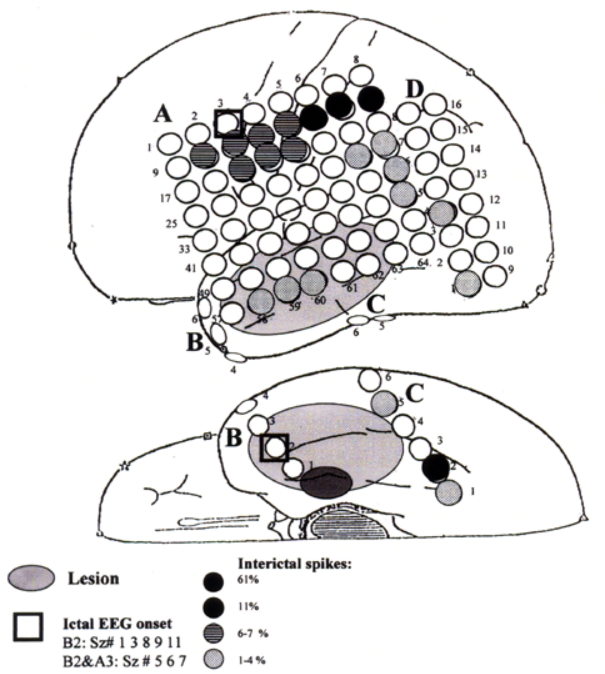

Fig. 4 The ictal EEG onset (quadrangle) and interictal epileptiform discharges (circle) recorded from the subdural electrode monitoring. B2 picked up the ictal EEG onset in all 8 seizures, 3 of which also simultaneously appeared at A3 contact. The IEDs were mostly recorded from upper A plate

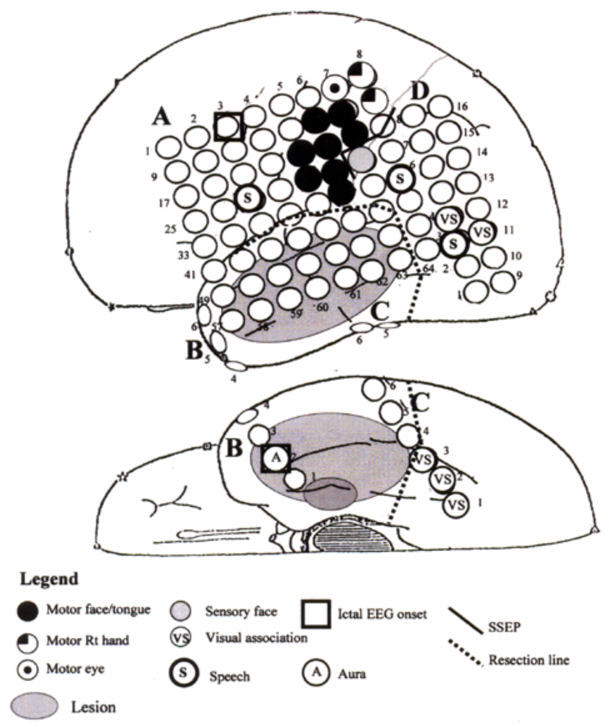

Fig. 5 Results of the cortical stimulation mapping showing functioning areas, SSEP and resection line

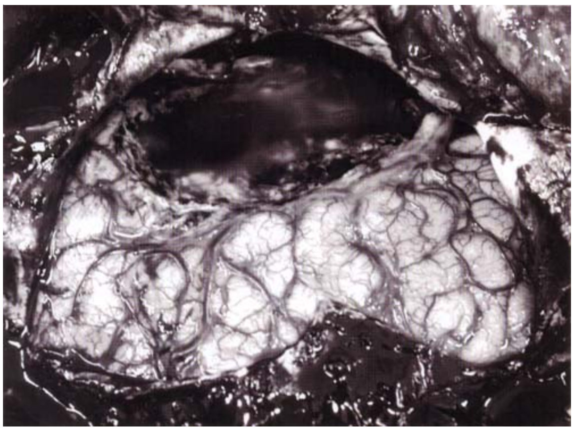

Fig. 6 Surgical resection of the identified epileptogenic zone outlined by the SDE monitoring and stimulation

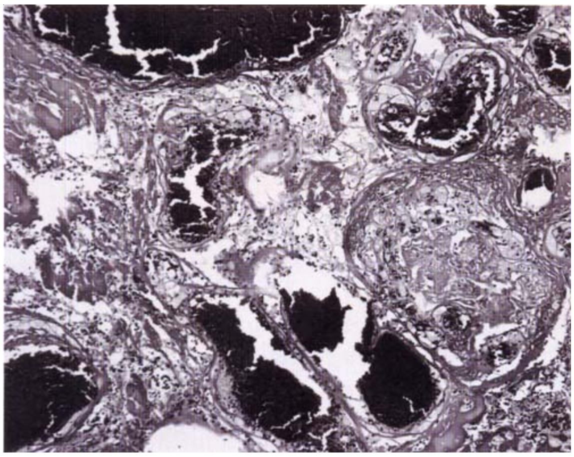

Fig. 7 H&E stain of the resective tissues showing radiation effects and a cavernous angioma

of seizure freedom without language deficit proved that the responsible epileptogenic zone was completely removed and the speech areas well preserved.

During the 1990s, there has been increasing interest in the surgical treatment of epilepsy. With the advent of modern neuroimagings especially MRI, preoperative epilepsy evaluation to localize the epileptogenic zone has been greatly improved. In a proportion of patients, noninvasive data can not localize epileptogenic zone nor define its relationship to the adjacent functioning cortices. Therefore, invasive EEG monitoring has been used to directly record the epileptiform activities over the brain surface or from the depth of the brain.

Penfield first used epidural electrodes to lateralize seizure onset in a patient with bitemporal lobe epilepsy in April 1939[3]. Subsequently, there have been many reports using invasive electrodes for seizure localization particularly subdural strips and grid electrodes[4,5]. The invasive electrode is indicated when the noninvasive evaluation shows unclear epileptogenic zone. The strip electrodes have low morbidity (0.85%) and are found to be effective in localizing epileptogenic focus[6,7]. Subdural grid electrodes have more advantage in covering a large area of cortical surface. Interictal, ictal EEG and functional mapping for example sensorimotor and speech functions can be obtained from chronically implanted subdural grid electrodes but with a higher morbidity compared with subdural strip or depth electrodes[8].

Cortical stimulation mapping via SDE has been used in adults as well as children who can not tolerate wake surgery with intraoperative stimulation[9]. The stimulation is performed extraoperatively; therefore is less stressful to the patients than the intraoperative awake procedure. However, the SDE risks the patients from two operations and complications such as brain edema, infection, bleeding and hemiparesis. Intraoperative awake operation can minimize the risks and costs of SDE monitoring, but requires highly cooperative subjects and is usually limited by time and paradigm given to an individual patient[10].

At the authors' epilepsy center, noninvasive presurgical evaluation has rendered more than 70% of the patients being suitable surgical candidates with good surgical outcomes. However, difficult cases have been accumulated including those with discordant data, nonlesional epilepsy, poorly circumscribed or multiple lesions and possible epileptogenic zone overlapping the functioning cortex or located in the dominant hemisphere. Therefore, invasive monitoring has been developed to further evaluate these patients for the chance of successful epilepsy surgery. This technique will identify more suitable surgical candidates rendering the best possible post operative outcome.

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การผ่าตัดใส่อิเลคโตรดในกะโหลกศีรษะสำหรับผ่าตัดโรคลมชักครั้งแรกในประเทศไทย

ธีรเดช ศรีกิจวิไลกุล, ชัยชน โลว์เจริญกุล, ทายาท ดีสุดจิต, ลาวัลย์ ตู้จินดา, สุกัลยา เลิศล้ำ, สุภัทรพร เทพมงคล, ชนพ โชติช่วง

โครงการรักษาโรคลมชักครบวงจรฯ โรงพยาบาลจุฬาลงกรณ์ได้ริเริ่มผ่าตัดโดยการใส่อีเลคโตรดในกะโหลกศีรษะเพื่อหาจุดกำเนิดของการชักและกระตุ้นสมองเพื่อหาตำแหน่งสมองที่สำคัญเพื่อรักษาโรคลมชักเป็นครั้งแรกในประเทศไทย ผู้ป่วยได้รับการผ่าตัดใส่อิเลคโตรดเพื่อหาจุดกำเนิดการชักและตำแหน่งสมองที่สำคัญ หลังการผ่าตัดเอาจุดกำเนิดการชักออก ผู้ป่วยไม่มีอาการชักเป็นเวลา 1 ปี หลังผ่าตัด