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Ictal wideband ECoG: Direct comparison between ictal slow shifts and high frequency oscillations

Hisaji Imamura [a], Riki Matsumoto [a], Morito Inouchi [a], Masao Matsuhashi [b], Nobuhiro Mikuni [c], Ryosuke Takahashi [a], Akio Ikeda [a,*]

[a] Department of Neurology, Kyoto University Graduate School of Medicine, Kyoto, Japan
[b] Human Brain Research Center, Kyoto University Graduate School of Medicine, Kyoto, Japan
[c] Department of Neurosurgery, Kyoto University Graduate School of Medicine, Kyoto, Japan

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HIGHLIGHTS

- Wideband electroencephalography (EEG) analysis by invasive electrodes, ictal slow shifts and high frequency oscillation (HFO) and its direct comparison can delineate the human epileptogenicity.
- Ictal slow shifts and HFOs in a patient with neocortical lobe epilepsy occurred earlier than conventional ictal EEG in subdural recording.
- Ictal slow shifts also preceded HFOs that may suggest an earlier and more active role of glia in seizure occurrence in human epilepsy.

ABSTRACT

Objective: With advanced electroencephalography (EEG) technology, 'wideband EEG' ranging from slow shift to high frequency oscillation (HFO) is clinically available to study human epileptogenesis. The purpose of our study is to clarify the relationship between slow shift, HFO and conventional electrocorticographic (ECoG) change.
Methods: A patient with right temporal lobe epilepsy who underwent presurgical evaluation with subdural electrodes was studied. Slow shift and HFO were evaluated in 16 habitual seizures with wideband EEG technique (bandpass filter of 0.016–600 Hz).
Results: Upon seizure occurrence in wideband ECoG, negative slow shifts coexisted with HFO (100–300 Hz) in the ictal onset zone in all investigated seizures. The former always preceded HFO and conventional initial EEG changes by mean value of 1.6 and 20.4 s, respectively. The slow shifts and HFOs were observed only in the restricted ictal onset zone.
Conclusions: In this particular patient, wideband EEG could delineate both ictal slow shift and HFO to define ictal onset zone, and the earliest occurrence of slow shifts may suggest an early role of glia in slow EEG shift generation than neurons.
Significance: The time difference of the onset between ictal HFO and slow shift may help to understand epileptogenesis.

1. Introduction

As electroencephalography (EEG) recording technology has advanced, we can get wideband EEG data from slow shift such as 0.01 Hz or below to high frequency oscillation (HFO) of several hundred hertz (Bragin et al., 2005). Ictal DC shifts or slow shifts were investigated in the 1960s in animals (Gumnit and Takahashi,1965) and they were reappraised in human epilepsy in the 1990s (Ikeda et al., 1996). Ictal slow shifts are not necessarily recorded by DC amplifier, but are well recorded by AC amplifier with a time constant of 10 s regardless of underlying aetiology or epilepsy type (Ikeda et al., 1996). (In this article, we use the term ictal slow shift when it was recorded by AC amplifier, and ictal DC shift when DC amplifier was used for recording). Ictal slow shifts are located in a more restricted area as compared with conventional EEG (Ikeda et al., 1999).

HFO has been recently studied extensively in the field of epilepsy surgery following investigations on normal cortical functions. HFO was initially investigated by the unit recording in

* Corresponding author. Address: Department of Neurology, Kyoto University Graduate School of Medicine, 54 Shogoin Kawahara-cho, Sakyo-ku, Kyoto 606-8507, Japan. Tel.: +81 75 751 3772; fax: +81 75 751 9416.
E-mail address: akio@kuhp.kyoto-u.ac.jp (A. Ikeda).

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experimental animal studies, but it was recently well recognised by means of both depth and subdural grid electrodes for field potential recording in the clinical field (Jacobs et al., 2008; Ochi et al., 2007). HFO of 80–250 Hz is called ripple and that of 250–500 Hz is called fast ripple. Fast ripple is regarded as being more related to ictal epileptogenicity at least in experimental animal studies (Bragin et al., 1999).

Based on the previous studies, it seems that both ictal slow shifts and HFOs are useful in detecting the epileptogenic zone, but the relationship between them is not clear and furthermore, a combined analysis has not been studied much so far (Modur and Scherg, 2009). The purpose of our study is to clarify the relationship between ictal slow shift, HFO and conventional electrocorticographic (ECoG) change, based on the case report.

2. Methods

The patient was a 20 year-old woman with right temporal oligodendroglioma and intractable partial epilepsy since the age of

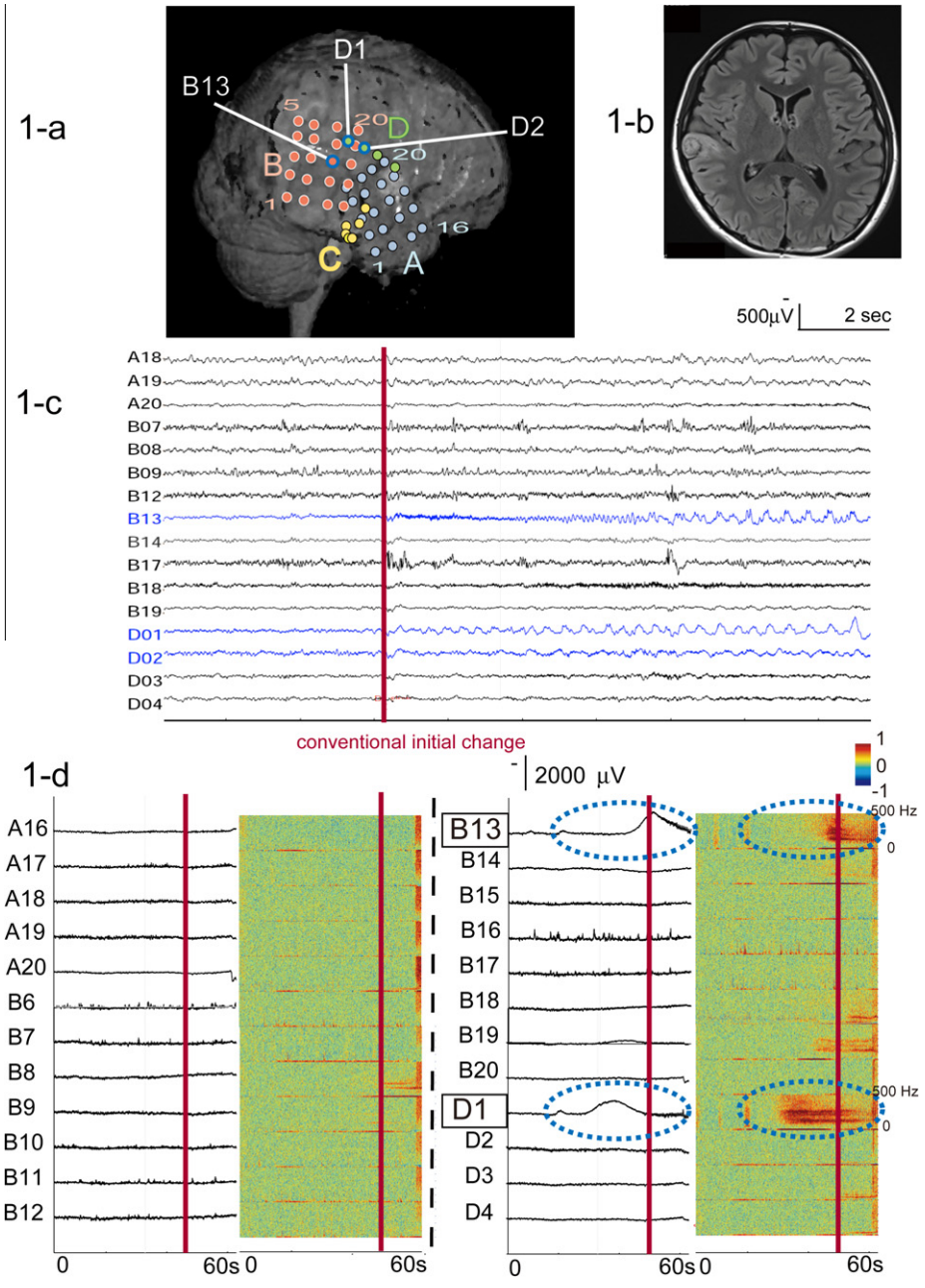

Fig. 1. (a) Placement of subdural electrode grids or strips. We put 50 electrodes on the right temporal lobe. Grid 'A' (4 × 5 electrodes) was placed on the right lateral temporal lobe, anterior part. Grid 'B' (4 × 5), the right lateral temporal lobe, posterior part. Strip 'C' (1 × 6), on the basal temporal area. Strip 'D' (1 × 4), within the Sylvian fissure. Initial change of conventional ictal ECoG was observed in the blue circled electrodes (D1, D2 and B13) with time constant of 0.1 s. (b) Pathologically diagnosed oligodendroglioma was located in right lateral temporal lobe, as shown by fluid attenuated inversion recovery (FLAIR) image. (c) Initial change of conventional ictal ECoG Three electrodes (D1, D2 and B13 at Fig. 1a), initially showed rhythmic, 2 Hz activities, as shown by the red vertical line, followed by the paroxysmal fast activities. We also showed the ECoG around the electrodes with initial change. (d) A pair of Ictal slow shifts (left: wave forms) and HFO (right: power spectrogram) in a representative seizure. Data from 24 electrodes are arranged into the two sets. Ictal slow shifts are shown with time constant of 10 s for ictal slow shifts. HFO is shown as the spectrogram from 0 to 500 Hz. All have the same 1-minute time window. Red vertical line was drawn at the onset of the conventional ictal ECoG change. Both ictal slow shift and HFO were observed in the same two electrodes (D1 and B13, blue dotted circle) and they preceded the conventional ECoG change.