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Spike voltage topography in temporal lobe epilepsy

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ABSTRACT

We investigated the voltage topography of interictal spikes in patients with temporal lobe epilepsy (TLE) to see whether topography was related to etiology for TLE. Adults with TLE, who had epilepsy surgery for drug-resistant seizures from 2011 until 2014 at Jefferson Comprehensive Epilepsy Center were selected. Two groups of patients were studied: patients with mesial temporal sclerosis (MTS) on MRI and those with other MRI findings. The voltage topography maps of the interictal spikes at the peak were created using BESA software. We classified the interictal spikes as polar, basal, lateral, or others. Thirty-four patients were studied, from which the characteristics of 340 spikes were investigated. The most common type of spike orientation was others (186 spikes; 54.7%), followed by lateral (146; 42.9%), polar (5; 1.5%), and basal (3; 0.9%). Characteristics of the voltage topography maps of the spikes between the two groups of patients were somewhat different. Five spikes in patients with MTS had polar orientation, but none of the spikes in patients with other MRI findings had polar orientation (odds ratio = 6.98, 95% confidence interval = 0.38 to 127.38; p = 0.07). Scalp topographic mapping of interictal spikes has the potential to offer different information than visual inspection alone. The present results do not allow an immediate clinical application of our findings; however, detecting a polar spike in a patient with TLE may increase the possibility of mesial temporal sclerosis as the underlying etiology.

1. Introduction

Since its inception, scalp electroencephalography (EEG) has been interpreted by visual inspection of waveforms using the assumption that activity at a given electrode is a representation of the activity of the cortex beneath it [1]. In many patients, this method of interpretation is sufficient to localize an interictal activity to one hemisphere or even one lobe, but such method has limitations and may lead to misinterpretation. Scalp EEG contains more information and the advent of digital EEG has allowed more advanced analysis of the EEG data. For example, spike voltage topography or 3-D voltage maps of cortical activity, is a descriptive way of defining dipole localization and orientation [1]. Interictal spikes are usually cortex negative, meaning the dipolar currents are flowing into the cortex. Therefore, a focal brain activity typically produces a dipolar field with two poles, a negative and a positive [2]. Often, the negative pole of a dipolar map is not exactly above the region of origin and may in fact be remote. Previous studies have suggested voltage mapping of interictal spikes as a way to improve non-invasive EEG localization of focal epilepsies [1,2]. This data can complement other localizing data (e.g., EEG visual inspection and seizure semiology). However, these studies noted that spike potentials could vary considerably [1] and the diagnostic value of this technique is remained to be elucidated.

The scope of this study is to describe 3-D voltage maps of interictal epileptiform activities in patients with temporal lobe epilepsy (TLE) to identify the prevalence of different patterns of spike voltage topography in these patients. We also investigated whether topography was related to etiology for TLE. This may shed light on the significance and clinical applicability of this technique to improve non-invasive EEG localization of temporal lobe epilepsies.

2. Methods

2.1. Patients

Adult patients with TLE, who had epilepsy surgery for drug-resistant seizures between January 2011 and January 2014 at Jefferson Comprehensive Epilepsy Center, were studied. Two groups of patients were studied, according to their magnetic resonance imaging (MRI) results: patients with mesial temporal sclerosis (MTS) and patients with other MRI findings. Patients with dual pathology, insufficient number of

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interictal spikes, or with psychogenic nonepileptic seizures were excluded from this study.

2.2. Measures

The long-term EEG recordings from preoperative evaluation were studied. In each patient, we identified ten interictal spikes in stages 1–3 of sleep. The first ten spikes in two different nights and on artifact free backgrounds were selected. If the patient had frequent spikes we selected a handful in each night. The topographic voltage maps of the designated spikes at the peak were created using BESA 3-D mapping software [2]. We classified the temporal spikes as 1) polar, if there was an oblique map with a negative pole on the cheek or around the eye and a positive pole in posterior head regions (Fig. 1); 2) basal, if activation presented itself with a near-vertical 3-D map with a strong negative pole at the ear or below and the positive pole near central electrodes (Fig. 2); 3) lateral, if there was a strong negative pole at or around the fronto-temporal (F7 or F8) or mid-temporal [T3 (T7) or T4 (T8)] electrodes and a positive pole at the opposite hemisphere (Fig. 3); and finally, 4) others, in all other circumstances.

2.3. Statistical analysis

Demographic variables and relevant clinical variables were summarized descriptively to characterize the study population. Chi square test and *t*-test were used for statistical analyses. Odds ratio and 95% confidence interval were calculated. p value < 0.05 was considered as significant.

2.4. Ethical approval

This study was conducted with approval by Thomas Jefferson University Institutional Review Board. No informed consent was required, as it was a retrospective study.

3. Results

Thirty-four patients were studied. Twenty-one patients had mesial temporal sclerosis, five had a normal MRI, and 8 patients had abnormal non-MTS MRI findings (3 patients had encephalomalacia/gliosis; 2 patients had tumors; 1 patient had cortical dysplasia; 1 had a cavernoma; and 1 patient had an encephalocele). Demographic and clinical characteristic of the patients are shown in Table 1. Characteristics and orientation of 340 interictal spikes were investigated. The most common type of spike orientation was others (186 spikes; 54.7%), followed by lateral (146; 42.9%), polar (5; 1.5%), and finally, basal (3; 0.9%). All patients had at least one spike with other polarity. Thirty-two patients (20 patients with MTS and 12 with other MRI findings) had at least one spike with lateral polarity. Three patients with MTS (14.3%) and one patient with other MRI finding (7.7%) had more than two spike populations with respect to polarity ($p = 0.4$). Characteristics of the voltage topography maps of the interictal spikes are

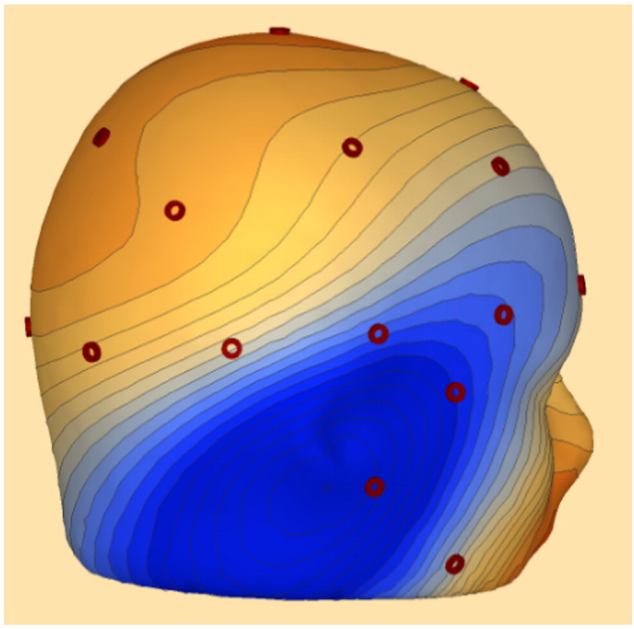

Fig. 2. A topographic map of a right anterior temporal sharp wave with basal orientation. Activation presented itself with a near-to-vertical topographic map with a strong negative pole below the ear and the positive pole near the vertex.

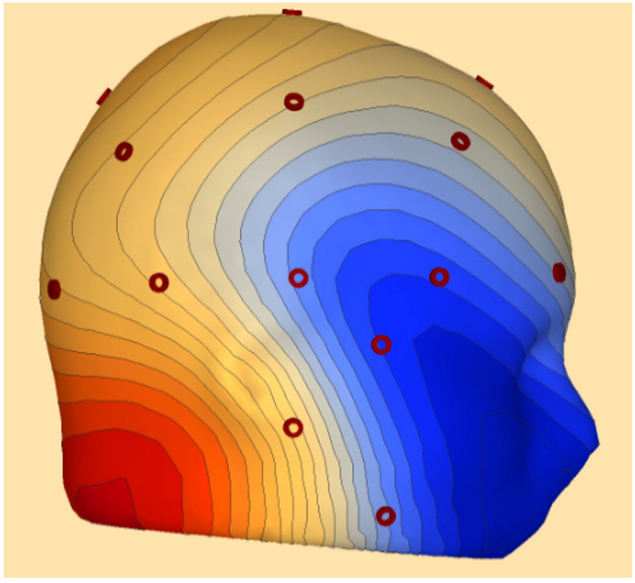

Fig. 1. A topographic map of a right anterior temporal sharp wave with polar orientation. A polar map with a negative pole around the right cheek and a positive pole in posterior head regions.

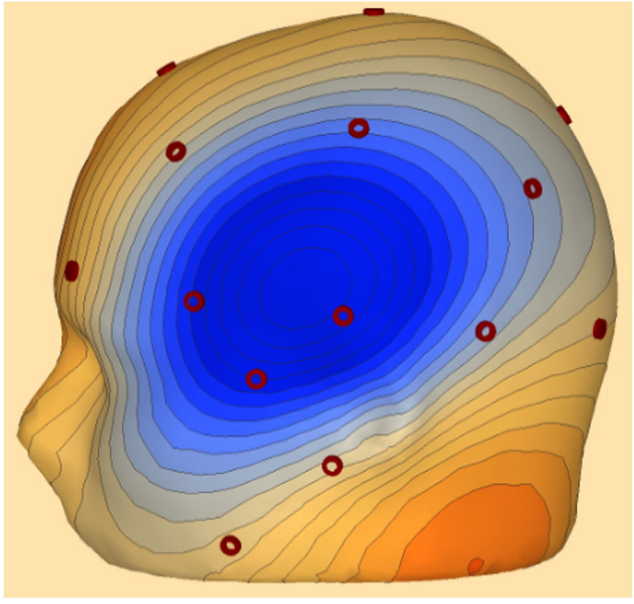

Fig. 3. A topographic map of a left mid-temporal spike with lateral orientation. The topographic map shows a left mid-temporal spike originating at the lateral cortical convexity near the T3 (T7) electrode. The corresponding positive pole is on the other side of the head.