Is inpatient ictal video-electroencephalographic monitoring mandatory in mesial temporal lobe epilepsy with unilateral hippocampal sclerosis? A prospective study

Marina K. M. Alvim | Marcia E. Morita | Clarissa L. Yasuda | Benito P. Damasceno | Tâtila M. Lopes | Ana Carolina Coan | Enrico Ghizoni | Helder Tedeschi | Fernando Cendes

Neuroimaging Laboratory, Department of Neurology, State University of Campinas, Campinas, São Paulo, Brazil

Correspondence
Fernando Cendes, Department of Neurology, University of Campinas - UNICAMP, Campinas, São Paulo, Brazil.
Email: fcendes@unicamp.br

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Summary

Objective: To compare surgical outcome in mesial temporal lobe epilepsy (MTLE) patients with unilateral hippocampal sclerosis (MTLE-HS) who had or did not have preoperative video-electroencephalographic monitoring (VEEG).

Methods: A prospective study was undertaken with 166 consecutive pharmacoresistant unilateral MTLE-HS patients. All patients were investigated with detailed seizure semiology, serial routine outpatient EEG, magnetic resonance imaging, neuropsychological evaluation, and if necessary, other examinations. Postoperative follow-up ranged between 2 and 16 years. Patients were divided into: (1) patients operated on based on routine outpatient EEG information, with >80% of EEGs with unilateral interictal epileptiform discharges (IEDs) ipsilateral to HS or ictal events (n = 71); and (2) patients submitted to preoperative VEEG (n = 95). To avoid the bias generated by ictal recordings, we performed a subanalysis of: (1) patients without preoperatively ictal recordings (n = 80) and (2) patients with ictal recordings in VEEG or routine outpatient EEG (n = 86).

Results: Groups were similar regarding gender, age at surgery, seizure onset, preoperative seizure frequency, and duration of follow-up. Overall, 136/166 (81.92%) were classified as Engel I seizure outcome, with no difference between groups; 76.84% and 88.73% of patients with and without VEEG, respectively, had Engel I postoperative seizure outcome (P = .77). The time lag until surgery was shorter in the group without VEEG (80 vs 38 months; P = .01). Considering ictal recordings, 76.74% of patients with seizures recorded and 87.50% without ictal recordings had Engel I outcome (P = .11).

Significance: We performed the first prospective study in a tertiary epilepsy center comparing surgical outcomes in unilateral MTLE-HS patients investigated preoperatively with and without VEEG. Based on the surgical outcome, VEEG is not imperative in patients with unilateral MTLE-HS who have compatible semiology and clearly ipsilateralized IEDs evaluated by a multidisciplinary and experienced epilepsy group.
1 | INTRODUCTION

Surgery is a well-established treatment for patients with mesial temporal lobe epilepsy (MTLE) and pharmacoresistant seizures. Early intervention is critical to prevent disabling consequences and for better prognosis. Unfortunately, patient access to tertiary centers rarely occurs at the beginning of the disorder.

The primary objective of preoperative workup is to determine the epileptogenic zone, and it is usually expensive and time-consuming. In MTLE, the presence of unilateral hippocampal atrophy and hyperintense T2-fluid-attenuated inversion recovery (FLAIR) signal on magnetic resonance imaging (MRI), which are indicative of hippocampal sclerosis (HS), has become the hallmark of this investigation. In addition, clinical history, seizure semiology, and interictal epileptic discharges (IEDs) on electroencephalograms (EEGs) are necessary to determine the epileptogenic zone. Traditionally, video-EEG monitoring (VEEG) is required to define the ictal zone. However, the real need for this examination in MTLE patients with clear MRI signs of unilateral HS has already been questioned. Strong concordance between interictal and ictal EEG findings with unilateral HS in the preoperative evaluation of patients with temporal lobe epilepsy (TLE) has been demonstrated. Concordant MRI and well-laterlized interictal EEG were also correlated with good surgical outcome, which means that the combination of these methods could correctly identify the epileptogenic zone.

There are a couple of studies evaluating surgical outcome of TLE patients who received surgery without VEEG, but none of them has investigated a homogeneous cohort of TLE patients with long-term postoperative evaluation comparing those with and without VEEG recordings. To examine this question further, we performed the first prospective study comparing surgical outcomes in unilateral MTLE-HS patients who had been investigated preoperatively with versus without VEEG monitoring.

2 | MATERIALS AND METHODS

This was a prospective, nonrandomized study that enrolled consecutive patients in a single epilepsy center (University of Campinas). We established a preoperative protocol for patients with MTLE who failed to respond to an adequate antiepileptic drug (AED) regimen, from October 1997 to July 2014, that consisted of detailed seizure semiology (with patient and family information), serial routine outpatient EEGs, high-resolution MRI with an epilepsy protocol described below, and neuropsychological evaluation. All patients were informed about the study and signed a written informed consent form approved by the ethics committee at the University of Campinas. Patients were classified as having MTLE according to the International League Against Epilepsy criteria.

All patients had ictal semiology described by a close relative or documented by medical staff during regular visits or VEEG monitoring. In addition, all had other clinical and EEG features consistent with the diagnosis of MTLE, and had no other findings suggesting an extratemporal focal epilepsy. The following criteria were met: (1) the clinical manifestations were indicative of MTLE, including stereotyped focal seizures with déjà vu or epigastric sensation, associated or not with fear and other autonomic symptoms (auras), followed by impaired awareness seizure, some with motor symptoms consisting of staring and lip smacking or masticatory automatisms or both, accompanied or not by hand automatisms and contralateral arm dystonia; (2) the EEGs during wakefulness showed no clear-cut epileptiform abnormalities outside the temporal lobe electrodes; and (3) there were epileptiform EEG abnormalities over temporal regions on interictal EEGs.
2.1 EEG protocol

Serial EEGs with at least 25 minutes of duration each, and sometimes up to 4 hours, were performed over several months in all patients. The EEGs were reviewed and reported by board-certified neurophysiologists from our epilepsy center, independently of the MRI diagnosis and before the final presurgical decision. Results were tabulated, and the records were stored in a digital archive. Temporal lobe IED was defined as focal spikes, sharp waves, or temporal intermittent rhythmic delta activity with a maximal involvement of electrodes T1/T2, F7/F8, and T3/T4. EEGs were coded as normal, abnormal with unilateral or bilateral IED, and with only intermittent slow waves.

2.2 Video-EEG protocol

Video-EEG was performed during 5 consecutive days and repeated during another 5 days if seizures were not recorded. Withdrawal of the AED was individualized depending on the type of AED, seizure frequency and type, and the presence of generalized tonic–clonic seizures and comorbidities. The VEEG records were stored in a digital archive, and reports were tabulated in our prospective database.

2.3 MRI acquisition protocol and analyses

HS was defined by visual analysis. HS signs were defined as hippocampal atrophy, hyperintense T2/FLAIR signal, and other MRI signs of HS, such as loss of internal architecture in the hippocampus.18 Hippocampal atrophy was independently confirmed by volumetry in most patients.

From 1997 to 2008, MRIs were performed on a 2.0-T scanner (Elscint Prestige, Haifa, Israel) with the following protocol: sagittal T1 spin-echo for optimal orientation of the subsequent images, 3-mm-thick T1 inversion recovery coronal slices (flip angle = 200°, repetition time [TR] = 2800 milliseconds, echo time [TE] = 14 milliseconds, inversion time = 840 milliseconds, matrix 130 × 256, field of view [FOV] = 160 × 180 mm); coronal 3-mm T2-weighted dual echo fast spin-echo images; axial T1-weighted and FLAIR images; and volumetric (3-dimensional [3D]) T1 gradient echo images, 1-1.5 mm thick, acquired in the sagittal plane for multiplanar reconstruction.

From 2009 to 2014, MRIs were acquired in a 3-T Intera Achieva scanner (Philips, Best, the Netherlands). The MRI protocol included 3D T1-weighted images (isotropic voxels of 1 mm for reconstruction in any plane, acquired in the sagittal plane; 1 mm thick, flip angle = 8°, TR = 7.0 milliseconds, TE = 3.2 milliseconds, matrix = 240 × 240, FOV = 240 × 240 mm) and T2-weighted multiecho coronal images (3 mm thick, TR = 3300 milliseconds, TE = 30/60/90/120/150 milliseconds, matrix = 200 × 180, FOV = 180 × 180 mm), as well as 3-mm-thick coronal T1-inversion recovery perpendicular to the long axis of hippocampus and FLAIR coronal and axial images.

2.4 Indication for surgery

Patients with unilateral MTLE-HS who failed to respond to 2 or more AEDs were enrolled for a preoperative evaluation that consisted of serial routine outpatient EEGs, as described above. While they waited for other preoperative examinations and evaluations, they were dichotomized into 2 groups:

1. Surgery without VEEG was performed if the patient had at least 10 EEGs with >80% of the recordings with unilateral IEDs ipsilateral to the HS, and consistent seizure semiology of MTLE without suspicion of nonepileptic events. Surgery was also indicated in those with <10 EEGs if seizures were captured in routine recordings, or if they had at least 6 consecutive EEGs with 100% of unilateral IEDs ipsilateral to the HS.

2. Video-EEG before surgery was indicated for patients who resided far from our center and had difficulty coming in for repeated routine EEG visits and when there was any doubt about seizure semiology, as well as several EEGs without interictal spikes or <80% with lateralized IEDs. Some of the patients (n = 34) who presented criteria to go to surgery without VEEG were also randomly submitted to VEEG monitoring.

A previous study observed that patients with >70% of EEGs having unilateral IEDs present strong agreement with MRI hippocampal volumetry lateralization,6 so to be more rigorous, we decided to consider patients with >80% of EEGs having unilateral IEDs for surgery without VEEG. Ictal single-photon emission computed tomography (SPECT) compared to interictal SPECT was performed in 15 patients who were submitted to VEEG monitoring (13 with hyperperfusion ipsilateral to the side of HS and 2 with nonlocalizing results). Neuropsychological evaluation was performed in all patients, with the primary objective to evaluate cognitive prognosis after surgery as well as part of the preoperative decision making. All decisions for proceeding with surgery were made during the discussion in our weekly seizure conference with the multidisciplinary professionals from our epilepsy service.

2.5 Surgical procedure

Patients were submitted either to selective transsylvian amygdalohippocampectomy or anterior temporal lobe resection surgery according to the neurosurgeon’s preference.
All patients who had sufficient specimen for evaluation had histopathological changes of HS.

2.6 | Patients’ postoperative follow-up and recording of seizure frequency

Patients were followed routinely in our epilepsy clinic every month for the first 2 months after surgery, every 2 months for the next 4 months, every 4 months for the next 2 years after surgery, and 6 months after that. In addition, all patients were requested to anticipate their visit or contact the service by a phone call in case of any new side effects, different symptoms, or change in seizure frequency. Patients were instructed to fill in a seizure calendar. We used a structured questionnaire to record seizure type and frequency, the medication used, side effects, and other relevant symptoms for all visits before and after surgery. Data were recorded on the patients’ medical chart and tabulated in our database. Surgical outcome was classified according to the Engel classification at least 2 years after surgery and updated at the last visit before the analyses of this study.

2.7 | Patients excluded from this study

We did not include TLE patients with dual pathology or with single lesions other than HS, patients with MRI signs of bilateral HS, patients with negative MRI, or patients with schizophrenia. Patients with <2 years of postoperative follow-up and those younger than 12 years (because the semiology of seizures is different in children) were not included. In addition, we excluded 1 patient who had 2 surgical procedures <2 years apart, so the surgical outcome after the first surgery could not be defined. Two patients with MTLE and HS were excluded because they did not undergo the full MRI protocol before surgery.

From the remaining 177 patients, we excluded 11 who presented associated nonepileptic events before and/or after surgery (see Table S1 for detailed clinical description and analysis of this subgroup), leaving a total of 166 patients for final analyses.

2.8 | Group analyses

We performed 3 analyses, described below.

2.8.1 | Analysis 1

In the first analysis, we compared 2 groups according to VEEG:

1. Patients without VEEG (n = 71) as described above.
2. Patients who had VEEG (n = 95).

2.8.2 | Analysis 2

As described above, during our preoperative evaluation, patients were submitted to serial routine outpatient EEG while they waited for others examinations such as VEEG. Therefore, a subgroup of patients was randomly selected to undergo VEEG even if they presented lateralized IED on routine EEGs. Therefore, we separated the group of patients who underwent VEEG into 2 groups, and then analyzed 3 different groups as follows:

Group 1: patients without VEEG (n = 71).
Group 2: patients who fulfilled our criteria to undergo surgery without VEEG (as described above), but randomly received VEEG (n = 34; 29 with lateralized interictal EEGs and 5 who had seizures during routine outpatient EEGs).
Group 3: patients who underwent VEEG before surgery because they did not fulfill the criteria of well-lateralized interictal EEGs (n = 61).

2.8.3 | Analysis 3

Because not all patients who were admitted to VEEG presented seizures during their admission and some patients presented seizures during the routine EEGs, we also performed a third subanalysis dividing patients into:

(A) Patients without recorded seizures preoperatively (n = 80): those who underwent surgery without ictal recordings. The surgical decision was based on interictal EEG information and other investigations.
(B) Ictal group (n = 86): patients who had seizures recorded during VEEG monitoring combined with those who had seizures recorded during routine EEGs.

2.9 | Statistical analysis

Statistical analysis was performed with SPSS software version 23.0 (IBM, Armonk, NY, USA). All numeric data had nonparametric statistical distribution according to Shapiro-Wilk test, except “duration of epilepsy until surgery.” Therefore, we used the 2-sample t test for comparing the duration of epilepsy and chi-square test or Wilcoxon-Mann-Whitney for the other variables. The relationships between age at surgery, age at seizures onset, preoperative frequency of seizures, time of postoperative evaluation, duration of epilepsy until surgery, and time lag until surgery were investigated using Spearman or Pearson product-moment correlation coefficient.
The number of routine EEGs performed (median = 12) was similar for both groups (P > .05). Twenty-eight (29.5%) patients with VEEG monitoring had unilateral IEDs on >80% of routine EEGs. From 71 patients in the group without VEEG, 16 (22.53%) had at least 1 lateralized ictal recording during routine EEGs. In the group with VEEG, 70 patients (73.68%) had seizures during the VEEG monitoring; 68 had lateralized seizures in VEEG, and 2 patients had no localizing or lateralizing events (nonspecific semiology and recording completely obscured by artifacts).

Overall, 136/166 (81.92%) patients were classified as Engel I seizure outcome; 70 (42.2%) patients were in Engel Ia, 15 (9.0%) in Engel Ib, 37 (22.3%) in Engel Ic, and 14 (8.4%) in Engel Id. The median postoperative follow-up for all patients was 6 years (ranging from 2 to 18 years).

### 3.1 Analysis 1: patients without VEEG monitoring versus those with VEEG monitoring

Both groups were similar regarding gender, age at surgery, age at seizures onset, and preoperative frequency of seizures, at the time of postoperative evaluation (Table 1).

Duration of epilepsy before surgery (P = .04) and the time lag between the first appointment in our service and date of surgery (P = .01) were longer for the group of patients with VEEG (Table 1). The proportion of patients who were submitted to selective transsylvian amygdalohippocampectomy or anterior temporal lobe resection was similar between groups (P = .87).

Surgical outcome was similar between groups; 73/95 patients (76.84%) with VEEG and 63/71 (88.73%) patients without VEEG presented as Engel I (P = .77, Figure 1). When comparing only patients with Engel Ia (free of all types of seizures since surgery, including auras), there were 38 (40%) patients in the group with VEEG and 27 (38%) patients without VEEG (P = .92). The different types of surgery also had a similar surgical outcome (P = .69).

### 3.2 Analysis 2: patients without VEEG monitoring versus those who received VEEG randomly versus patients who needed and received VEEG

The groups were similar regarding gender, age at surgery, age at seizures onset, preoperative frequency of seizures, duration of epilepsy, and time of postoperative evaluation. The clinical data are displayed in Table 2. In the group of patients who received VEEG randomly, 4 had seizures during the routine EEG and VEEG, and 1 had the ictal recording only during routine EEG, and no seizures during the VEEG monitoring. The other 29 patients presented lateralized IED on the routine EEG.

These 3 groups presented the same outcome (P = .143), as demonstrated in Figure 2. The different types of surgery also had similar surgical outcome (P = .685).

### 3.3 Analysis 3: patients without seizures recorded versus patients with ictal recordings

To avoid the bias generated by ictal recording during routine EEG or VEEG without lateralized seizure records, we also evaluated patients with and without ictal recordings. Clinical data of these groups are presented in Table 3.

There was no difference in surgical outcome between these subgroups; 66/86 patients (76.74%) from the subgroup with seizures recorded and 70/80 (87.5%) from those who were operated on without ictal recordings were in Engel I (P = .11, Figure 1). There was also no difference in the proportion of Engel Ia (complete seizure freedom including auras) between subgroups (41.3% in the group with ictal recordings and 37.2% in the group without; P = .71).

The postoperative follow-up was longer in the group with preoperative ictal recordings (P = .016, Table 3).

### 4 Discussion

Our study demonstrated that surgical outcome in selected MTLE patients with unilateral MRI signs of HS, no suspicion of nonepileptic events, and >80% of serial outpatient EEGs having unilateral IEDs was not influenced by VEEG monitoring or ictal recordings. Our results add an important piece of evidence for the extensive debate about the value of VEEG evaluation of MTLE patients with MRI signs of unilateral HS.

Video-EEG is unquestionably valuable in epilepsy evaluation, mainly for defining paroxysmal events as epileptic or not, localizing seizure onset, characterizing epileptic syndrome, and even determining AED adjustments. In MTLE presurgical evaluation, video-EEG is helpful in defining whether paroxysmal events are actually epileptic and in localizing seizure onset. However, it is not the only way to elucidate these presurgical matters, because the presurgical investigation for epilepsy is multimodal and multidisciplinary, and other sources of evidence, including outpatient EEG evidence for a single focus, can obviate the need for ictal recordings.

The irritative zone that corresponds to EEG IEDs has helped to determine the seizure onset region since the early years of the surgical treatment of epilepsies, although this zone is considered to be more widespread than the seizure
onset region. Studies have demonstrated that IEDs are confined to the temporal lobe in patients with bilateral or unilateral HS, and that IEDs localized to 1 temporal lobe on serial routine EEGs or during long-term monitoring may be sufficient to localize the epileptogenic zone in patients with MRI-defined unilateral HS. In addition, there is evidence that concordant interictal recordings and MRI in MTLE HS patients have a good power of prediction of the seizure onset region. Supporting this idea, the concordance between MRI and IEDs was also associated with good surgical outcomes. More recent studies using simultaneous EEG with functional MRI to evaluate the blood oxygenation level-dependent (BOLD) signal related to IEDs indicate that seizures and IEDs are generated by the same neuronal network, explaining why IEDs related to BOLD responses are a good predictor of surgical outcome. Therefore, IEDs are valuable biomarkers to determine the seizure onset region in patients with TLE-HS.

FIGURE 1 Surgical outcome: patients with and without preoperative video-electroencephalographic (VEEG) and ictal recordings. Surgical outcomes in both groups were similar considering Engel I outcome in the groups of patients with and without VEEG (P = .77, chi-square test) and in patients with and without lateralized ictal recordings (P = .72, chi-square test). The figure shows the distribution of all surgical outcomes.

TABLE 1 Clinical data comparing patients with and without VEEG monitoring in the preoperative investigation

<table>
<thead>
<tr>
<th></th>
<th>With VEEG</th>
<th>Without VEEG</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>95</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Male: 39 (41.1%)</td>
<td>Male: 31 (43.7%)</td>
<td>.86&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>Female: 56 (58.9%)</td>
<td>Female: 40 (56.3%)</td>
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<tr>
<td>HS side on MRI</td>
<td></td>
<td></td>
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<tr>
<td>Right HS: 50 (52.6%)</td>
<td>Right HS: 34 (47.9%)</td>
<td>.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Left HS: 45 (47.4%)</td>
<td>Left HS: 37 (52.1%)</td>
<td></td>
<td></td>
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<tr>
<td>Age at epilepsy onset, median y (range)</td>
<td>6 (0-30)</td>
<td>5 (0-30)</td>
<td>.52&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Age at surgery, median y (range)</td>
<td>39 (13-57)</td>
<td>41 (12-66)</td>
<td>.22&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Number of routine outpatient EEGs, median (range)</td>
<td>11 (1-33)</td>
<td>11 (5-28)</td>
<td>.30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
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<td>Preoperative frequency of seizures with impairment of awareness, median (range)</td>
<td>5 seizures/mo (1-120)</td>
<td>8 seizures/mo (1-120)</td>
<td>.06&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Time lag from 1st appointment to surgery, median mo (range)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>80 (6-264)</td>
<td>38 (9-298)</td>
<td>.01&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Duration of epilepsy, average y (range)</td>
<td>30 (1-55)</td>
<td>34 (9-59)</td>
<td>.04&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>Postoperative evaluation, median y (range)</td>
<td>6 (2-18)</td>
<td>6 (2-15)</td>
<td>.33&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

EEG, electroencephalography; HS, hippocampal sclerosis; MRI, magnetic resonance imaging; VEEG, video-EEG. Significant P-values are marked in bold.

<sup>a</sup>Chi-square.
<sup>b</sup>Mann-Whitney test.
<sup>c</sup>After all investigations were completed in either scenario, some of these patients decided not to undergo surgery, and years later they changed their mind and were operated on. This explains the large variation between the first visit and date of surgery.
<sup>d</sup>t test.
TABLE 2  Clinical data comparing patients without VEEG monitoring, those who underwent VEEG, and those who underwent VEEG randomly during the preoperative investigation

<table>
<thead>
<tr>
<th></th>
<th>Group 1: patients without VEEG</th>
<th>Group 2: patients who underwent VEEG randomly</th>
<th>Group 3: patients who needed and underwent VEEG</th>
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<td>Number of patients</td>
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<td>34</td>
<td>61</td>
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<td>Gender</td>
<td>Male: 31 (43.7%)</td>
<td>Male: 12 (35.3%)</td>
<td>Male: 27 (44.3%)</td>
<td>.659</td>
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<tr>
<td></td>
<td>Female: 40 (56.3%)</td>
<td>Female: 22 (64.7%)</td>
<td>Female: 34 (55.7%)</td>
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<tr>
<td>HS side on MRI</td>
<td>Right HS: 34</td>
<td>Right HS: 15</td>
<td>Right HS: 35</td>
<td>.386</td>
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<td></td>
<td>Left HS: 37</td>
<td>Left HS: 19</td>
<td>Left HS: 26</td>
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<td>Surgery</td>
<td>Selective: 30</td>
<td>Selective: 12</td>
<td>Selective: 27</td>
<td>.688</td>
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<tr>
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<td>(range)</td>
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<td>(range)</td>
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<tr>
<td>Age at surgery</td>
<td>41 (12-66)</td>
<td>38 (17-57)</td>
<td>39 (13-57)</td>
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<td>Number of routine</td>
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<td>(range)</td>
<td>(range)</td>
<td>(range)</td>
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<tr>
<td>Preoperative frequency</td>
<td>8 seizures/mo (1-120)</td>
<td>4 seizures/mo (1-30)</td>
<td>5 seizures/mo (1-120)</td>
<td>.143</td>
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<td>of seizures with</td>
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<td>impaired awareness,</td>
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<tr>
<td>median (range)</td>
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<tr>
<td>Time lag from 1st</td>
<td>38 (9-298)</td>
<td>90 (12-227)</td>
<td>70 (6-264)</td>
<td>.021</td>
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<td>surgery, median mo</td>
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<td>(range)</td>
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<td>Duration of epilepsy</td>
<td>34 (9-59)</td>
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<td>, mean y (range)</td>
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EEG, electroencephalography; HS, hippocampal sclerosis; lobectomy, anterior temporal lobe resection; MRI, magnetic resonance imaging; selective, selective trans-sylvian amygdalohippocampectomy; VEEG, video-EEG. Significant P-values are marked in bold.

*aChi-square.

*bMann-Whitney test.

*cAnalysis of variance.

FIGURE 2  Surgical outcome in patients without video-electroencephalographic (VEEG) monitoring versus those who underwent VEEG versus those who underwent VEEG randomly during preoperative investigation. There were no differences in Engel I surgical outcomes among groups. Group 1 = patients without VEEG. Group 2 = patients who have criteria to go to surgery without investigation with VEEG but randomly underwent VEEG. Group 3 = patients who underwent VEEG before surgery because they did not fulfill our criteria for unilateral interictal electroencephalographic findings (P = .143, Pearson test). The figure shows the distribution of all surgical outcomes.
of expertise and is not recommended outside well-established epilepsy centers.

It is also important to discuss whether the typical 2 weeks in-hospital VEEG is adequate to evaluate the lateralization of ictal activity in TLE. In 82 bilateral MTLE subjects submitted to long-term continuous ambulatory electrocorticography (Neuropace study), 28% of patients had independent bilaterally recorded seizures. The average time to record the contralateral seizure was 41.6 days, which indicates that most of these TLE-HS patients would need >1 month in VEEG monitoring to define the presence of bilateral independent seizures. Besides that, EEG evaluation with full medication is more reliable than soon after AED withdraw, and VEEG is usually performed after AED withdraw to shorten the inpatient period and to induce seizures, increasing the odds of recording bilateral or false lateralizing EEG changes. Therefore, it is possible that classical VEEG monitoring with 2- or 3-week duration is not sufficient to lateralize seizures in TLE patients with possible bilateral seizures and sometimes may even exclude good candidates for surgery.

Another important role of VEEG is to identify nonepileptic events. It is important to emphasize that psychogenic nonepileptic seizure (PNES) is a complex entity, and its investigation should include the medical and social patient history, seizure semiology, and psychiatric evaluation whenever nonepileptic events are suspected. There is a strong association with neurological and psychiatric disorders, and 5%-40% of patients with PNES also present epileptic seizures. PNES may be captured also in routine outpatient EEGs (which nowadays may be easily done with simultaneous video recording), as was the case for some of our patients. One study demonstrated that short-term VEEG (3- or 4-hour duration) have even higher yield for recording PNES than epileptic seizures. Interestingly, 1 study suggests that there exists a dichotomy of PNES patients in VEEG; some present their spells as soon as the examination starts, whereas others do not have PNES, even in prolonged monitoring. Therefore, long-term VEEG can help to identify PNES, but cannot exclude its existence. Furthermore, good characterization of the event and past medical, social, and psychiatric history made by a multidisciplinary epilepsy group, as well as routine outpatient EEGs, can be very helpful to identify PNES.

It is also important to consider that VEEG is expensive and uncomfortable for the patient, and involves seizure-associated risks, such as seizure clusters (23%-48% of patients), prolonged seizures, status epilepticus (1%-3%), fractures and accidents, and even sudden unexpected death in epilepsy, although it is rare. Furthermore, VEEG accomplished the goal of admission in just 18%-23% of patients. Our study demonstrated that MTLE patients who did not have VEEG underwent surgery earlier than those who had VEEG. One bias of our study is that postoperative evaluation was longer in the group with ictal recordings. It is known that outcome is influenced by the duration of follow-up; however, one long-term evaluation study demonstrated that only 57% of patients who were
controlled in the first years remained seizure-free after 5 years and 51% after 10 years.\textsuperscript{38} Another difference in our study was that duration of epilepsy was higher in the group of patients without VEEG monitoring; however, the outcome was not different in this group. Another limitation is that this was not a classical randomized study, which is difficult in this clinical setting. However, the groups were well balanced concerning their clinic characteristics, and a subgroup of patients was randomly selected to VEEG, allowing us to minimize this shortcoming.

We showed evidence that, for experienced epileptologists, it is possible to safely indicate epilepsy surgery without in-patient VEEG in a selected group of MTLE patients with unilateral MRI signs of HS, clinical semiology compatible with diagnosis, no suspicion of nonepileptic events, and a sufficient number of outpatient EEGs with clear lateralized IED ipsilateral to HS. These findings should be interpreted with caution and not be applied to patients with bilateral HS, negative MRI, or other types of epilepsies.

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DISCLOSURE OF CONFLICT OF INTEREST

M.E.M. has acted as a consultant to UCB Pharma. F.C. serves on the editorial boards of Neurology, Epilepsia, Epilepsy Research, Epilepsy & Behavior, and Frontiers in Neurology; and has acted as a consultant to UCB Pharma. The other authors have no disclosures. We confirm that we have read the Journal’s position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

ORCID

Fernando Cendes \textsuperscript{12} http://orcid.org/0000-0001-9336-9568

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