Diagnostic yield of inpatient video-electroencephalographic monitoring: Experience from a Chinese comprehensive epilepsy center

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A R T I C L E   I N F O

Article history:
Received 13 December 2013
Revised 13 February 2014
Accepted 12 March 2014
Available online 12 April 2014

Keywords:
Epilepsy
Diagnosis
Video-electroencephalographic monitoring

A B S T R A C T

Video-electroencephalographic monitoring (VEEG) is useful in the diagnosis of seizure disorders; however, its diagnostic yield in developing countries is not well known. The current study retrospectively reviewed the charts of 484 consecutive patients who were admitted to our center between July 2012 and September 2013. Of these patients, 298 (61.6%) were admitted for diagnostic clarification and underwent VEEG for a mean duration of 1.3 days (range = 1–9 days). The patients were divided into two groups: those whose diagnosis was changed and those whose diagnosis was not changed as a result of VEEG. A patient with a prediagnosis of epilepsy who was discharged with a diagnosis of nonepileptic events (NEEs) or who was further classified as focal/generalized epilepsy on discharge was included in the “change in diagnosis” group. A patient admitted with an uncertain diagnosis and discharged with a diagnosis of NEEs or epilepsy (including focal epilepsy and generalized epilepsy) was also included in the “change in diagnosis” group. Video-electroencephalographic monitoring recorded typical ictal events (epileptic events or nonepileptic events) in 147 (49.3%) of the patients admitted for diagnostic clarification. In total, 181 (60.7%) patients had a change in diagnosis after VEEG. Among them, 103 (36.9%) patients had a prediagnosis of epilepsy, which was further classified as focal epilepsy (88 patients) or generalized epilepsy (15 patients); the diagnosis of NEEs and epilepsy was clarified in 78 (43.1%) patients. The number of patients diagnosed with NEEs increased from 31 (10.4%) on admission to 88 (29.5%) on discharge. Among all the patients admitted for diagnostic clarification, therapeutic plans were changed for 104 (57.5%) patients. In 117 (39.3%) patients with no diagnostic change, VEEG evaluation provided confirmative diagnostic information in 47 (15.8%) patients and no additional diagnostic information in 70 (23.5%) patients. The study indicates that VEEG is useful in terms of clarifying seizure diagnoses and evaluating seizure frequency. In our cohort study, VEEG of a relatively short mean duration produced a comparable diagnostic yield as that reported in other studies.

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1. Introduction

Epilepsy affects 1% of the population, and 20%–30% of patients with epilepsy have medically intractable disease [1,2]. Misdiagnosis of epilepsy is not uncommon since the symptoms of epileptic seizures are varied, and many disorders mimic its symptoms, including organic nonepileptic events (ONEEs) and psychogenic nonepileptic seizures (PNEEs). The diagnosis of epilepsy largely depends on careful history taking. However, the description of seizures based on a history can sometimes be misleading and can lead to errors in diagnosis and subsequent treatment [3,4]. Routine electroencephalography (EEG) is not always helpful because, in some patients, interictal epileptiform discharges (IEDs) are absent or infrequent; only 25%–56% of patients with epilepsy show IEDs during a 20-min EEG recording [5]. Moreover, IEDs are suggestive of but not diagnostic of epilepsy.

Video-electroencephalographic monitoring (VEEG) for a long duration is able to capture both typical events and infrequent IEDs. Video-electroencephalographic monitoring has been used for many years in the diagnostic classification of paroxysmal spells and the classification of epilepsy types as well as presurgical evaluation [6]. Moreover, it is considered the “gold standard” in the diagnosis of seizure disorders. Although VEEG is costly and time-consuming, it is associated with long-term benefits such as diagnostic confirmation and selection of appropriate antiepileptic drugs (AEDs). Although the utility of VEEG has been reported in several studies [7,8], data from developing countries are still limited [9]. Here, we reviewed the changes in the diagnosis of the patients admitted for diagnostic clarification in our epilepsy center,

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http://dx.doi.org/10.1016/j.yebeh.2014.03.010
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where most patients underwent VEEG for at least 24 h. The purpose of the study was to determine the utility of VEEG in our center.

2. Materials and methods

2.1. Patients and data extraction

Our epilepsy center is a newly founded multidisciplinary department that specializes in the diagnosis and treatment of complex and intractable epilepsy. The center mainly receives patients referred by doctors across Zhejiang Province and neighboring areas and by neurologists and neurosurgeons at our hospital. The center has nine inpatient beds, five of which are equipped with digital video-EEG machines. Patients underwent VEEG for one of three purposes: (1) discrimination between epileptic and nonepileptic spells or the classification of epileptic seizures (diagnostic clarification), (2) medication adjustment, and (3) presurgical evaluation. Medications were not changed during VEEG of the patients admitted for diagnostic clarification. The study was approved by the ethics committee of our hospital.

We retrospectively reviewed the medical charts, including VEEG reports, of 484 consecutive patients admitted to our center between July 2012 and September 2013. The information extracted from the charts included the demographic profile and history of the patients, the reason for the referral, the diagnoses on admission and discharge, and the VEEG reports.

2.2. VEEG procedure

Video-electroencephalographic monitoring was performed using digital VEEG systems (Nicolet, VIASSYS, USA; Biologic, NATUS, USA), with scalp electrodes placed according to the international 10/20 system. Additional scalp electrodes or sphenoidal electrodes were used if necessary. Activation tasks, including hyperventilation and photic stimulation, were routinely performed. All the patients had natural sleep during the recording. Videos were recorded by using two digital cameras, and the patients were continuously monitored throughout the day and night. Patients and their family members were encouraged to press the seizure alarm button for any suspicious events. If any event was observed during monitoring, the medical staff quickly came into the monitoring room and interviewed the patient to assess their consciousness and their ability to speak.

The patients admitted for diagnostic clarification or medication adjustment were monitored for at least 24 h. If the typical events were not captured in the first day and the event frequency was high enough, a longer monitoring time was recommended and was performed if the patients agreed. The patients who underwent presurgical evaluation were monitored for 1–14 days to observe an adequate number of seizures. The VEEG results were analyzed by epileptologists and EEG technicians together, and the report was finalized by the epileptologists. For complicated cases, consensus was reached by most epileptologists at a weekly patient management conference. All the epileptologists had been formally trained at recognized epilepsy centers, including the Cleveland Clinic Epilepsy Center (Ohio, USA) and the National Epilepsy Center (Shizuoka, Japan). The patients underwent a 3-T brain magnetic resonance imaging (MRI) scan with an epilepsy-specific protocol, if their routine outpatient brain MRI (1.5-T or 3.0-T) results were normal or showed a nonspecific abnormality. The diagnosis was classified according to the guidelines of the International Classification of Epileptic Seizures and the International Classification of Epilepsy and Epileptic Syndromes [10,11].

To analyze the diagnostic yield of VEEG, the patients admitted for diagnostic clarification were divided into two groups: change in diagnosis versus no change between the preadmission diagnosis and the discharge diagnosis. The change in diagnosis was defined as follows: (1) patients with a preadmission diagnosis of epilepsy who were discharged with a diagnosis of nonepileptic events (NEEs), (2) patients admitted with an uncertain diagnosis and then discharged with a diagnosis of NEEs or epilepsy (including focal epilepsy and generalized epilepsy), and (3) patients with a preadmission diagnosis of unclassified epilepsy who were further classified as focal/generalized epilepsy on discharge.

3. Results

3.1. Patient characteristics and referral objectives

A total of 484 admissions were reviewed (Fig. 1). Among them, 298 patients were admitted for diagnostic clarification. Of those patients, the final diagnosis was epilepsy (including epilepsy subtypes) in 197 (66.1%) patients, NEEs in 88 (29.5%) patients, and uncertain in 13 (4.4%) patients (Table 1). There were 161 (54.0%) males and 137 (46.0%) females. The mean age of these patients was 28.7 years (SD = 17.7 years; range = 3–85 years), and the mean disease course was 63.3 months (SD = 8.4 months; range = 1–444 months). A routine outpatient EEG test was available for 161 (54.0%) of these patients, of whom 71 (23.8%) had “epileptiform discharges”. On admission, 145 patients were on AEDs, accounting for 75.1% of the 193 patients with a preadmission diagnosis of epilepsy, which included 95 (65.5%) who were on monotherapy, 33 (22.8%) who were on dual therapy, and 17 (11.7%) who were on polytherapy.

3.2. Interictal and ictal VEEG findings

Among the patients who were admitted for diagnostic clarification, the mean monitoring duration was 1.3 days (SD = 0.8 days; range = 1–9 days). During VEEG, IEDs were detected in 131 (44.0%) patients, of whom 15 (11.5%) patients showed IEDs suggestive of generalized epilepsy and 116 (88.5%) patients mainly showed IEDs suggestive of focal epilepsy. Ictal events (epileptic events or nonepileptic events) were recorded in nearly half of the patients (147 (49.3%) out of the 298 patients), only epileptic events and only nonepileptic events were recorded in 67 (22.5%) patients and 77 (25.8%) patients, respectively, and both epileptic events and nonepileptic events were recorded in the remaining 3 (1%) patients. Of those patients who had ictal (epileptic or nonepileptic events) events, 66.2% had their first event during the first 24 h, and 20.3% had their first event during the next 24 h. In addition, in eight patients, VEEG revealed some type of epileptic seizure that was not noticed by the patients themselves or their families. All these “neglected seizure types” were complex partial seizures, and most of them occurred at night. In addition, EEG seizures without obvious clinical signs were detected in four patients with epilepsy.

![Fig. 1. Distribution of patients according to objectives of referral for VEEG.](image-url)
3.3. Changes in diagnosis

Among the patients who were admitted for diagnostic clarification, 181 (60.7%) patients had a change in diagnosis after VEEG (Fig. 2), and their mean monitoring duration was 1.27 days (SD = 0.76 days). In these patients, VEEG helped in differentiating between epilepsy and NEEs in 78 patients; it also helped in further classifying focal and generalized epilepsy in 103 patients with a diagnosis of epilepsy on admission. Of these 103 patients, 15 were diagnosed with epilepsy syndromes, including 11 patients with benign focal epilepsy of childhood, two with juvenile myoclonic epilepsy, and two with childhood absence epilepsy. This further classification of epilepsy was successfully aided by IED features in 55 patients, by ictal electroclinical features in 13 patients, and by both IED and ictal features in 35 patients.

Seventeen patients with a preadmission diagnosis of epilepsy (or epilepsy subtypes) were diagnosed with NEEs after VEEG, including ten patients with psychogenic nonepileptic seizures, two with dizzy spells, three with movement disorders, one with a sleep disorder, and one with hypoglycemic attacks.

Of the 181 patients who had a change in diagnosis, 104 (57.5%) patients required a change in therapeutic plans; these changes included an adjustment in AEDs, the introduction or withdrawal of antianxiety or antidepressant medications, and psychiatric consultation. Therapeutic plans were also changed for the 17 patients who were diagnosed with epilepsy on admission but diagnosed with NEEs after VEEG. Antiepileptic drugs were withdrawn or their doses were decreased on discharge in these patients, except for two patients with PNEEs in whom delayed withdrawal of AEDs was recommended.

Among the patients who were admitted for diagnostic clarification, 117 patients did not have a diagnosis change after VEEG. Their mean monitoring duration was 1.18 days (SD = 0.65 days), which is not significantly shorter than that of the patients with a diagnosis change (Mann–Whitney for nonparametric test, p > 0.05). Video-electroencephalographic monitoring provided no additional diagnostic information for 70 patients in whom neither IEDs nor typical events were observed during monitoring. Accordingly, their therapeutic plans were not changed.

Video-electroencephalographic monitoring helped confirm the diagnosis in another 47 patients. Among them were 28 patients with a preadmission diagnosis of focal epilepsy who exhibited IEDs and/or ictal electroclinical features that indicated focal epilepsy. In the other 19 patients, who had NEEs, IEDs were absent, and typical events were recorded without EEG changes. In the 28 patients for whom the VEEG results confirmed the diagnosis, AEDs were adjusted in 18 patients. One reason for adjusting AEDs was that VEEG found a higher frequency of epileptic seizures than that reported in the patient history.

4. Discussion

In our epilepsy center, 61.6% of the admissions were made for the purpose of diagnostic clarification of seizure disorders, which is similar to the percentage reported by a British tertiary epilepsy referral unit [8]. We found that inpatient VEEG provided useful diagnostic information that helped clarify the seizure diagnosis and evaluate seizure frequency. Video-electroencephalographic monitoring resulted in a change in diagnosis in 60.7% of the patients admitted for diagnostic clarification. It also confirmed the diagnosis in 15.8% of the patients. It provided no additional diagnostic information in the remaining 23.5% of the cohort. Furthermore, it was also helpful for evaluating actual seizure frequency and identifying seizure types that were unrecognized by patients and their families, especially complex partial seizures that occurred at night.

The diagnostic yield of VEEG, with a mean duration of 1.3 days, in our study is comparable with that obtained in previous reports. Ghougassian et al. reported that 58% of 131 patients had a change in diagnosis after VEEG, with a mean duration of 5.6 days [7]. In a study in a British tertiary epilepsy referral unit, VEEG with a mean duration of 2.9 days led to a change in diagnosis in 71% of 230 patients with paroxysmal behavioral events [8]. If the patients with “refinement of diagnosis” are removed from the analysis, 58% of patients had a “true” diagnosis change. We did not assess “refinement in diagnosis” in our

**Table 1**

<table>
<thead>
<tr>
<th>Diagnosis Before VEM</th>
<th>After VEM</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
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<td>115</td>
</tr>
<tr>
<td>Focal</td>
<td>46</td>
<td>154</td>
</tr>
<tr>
<td>General</td>
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<td>16</td>
</tr>
<tr>
<td>Unclassified</td>
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<td>27</td>
</tr>
<tr>
<td>NEEs</td>
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<td>19</td>
</tr>
<tr>
<td>PNEEs</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Syncope</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Movement disorders</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Sleep disorders</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td>Others</td>
<td>74</td>
<td>13</td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 2.** The types of changes in diagnosis after VEM. NEEs: nonepileptic events.
study because lobar localization of focal epilepsy does not provide further guidance for medical treatment. Yogarajah’s study [8] included a subgroup of “refinement in diagnosis” in which the patients with focal epilepsy were further classified as lobar epilepsy, for example, frontal epilepsy. If the patients with “refinement of diagnosis” are removed from the analysis, 58% of patients had a “true” diagnosis change.

In our study, 103 (34.6%) patients of all the patients admitted for diagnostic clarification with a preadmission diagnosis of epilepsy were further classified as having focal epilepsy (88 patients) or generalized epilepsy (15 patients). Before admission, neither the historical information nor the routine EEG results were sufficient to differentiate between focal epilepsy and general epilepsy. The further classification of epilepsy subtypes by VEEG brought benefits in medical treatment. For example, carbamazepine or phenytoin was withdrawn in four patients who were finally diagnosed with absence epilepsy or myoclonic epilepsy, which greatly reduced the severity of their seizures. Aggressive treatment with AEDs was avoided in patients diagnosed with benign focal epilepsy of childhood with centrocerebral spikes. In the present study, the 101 patients with a further classification of epilepsy subtypes accounted for 56.9% of all patients with a diagnostic change (n = 181), whereas this percentage was lower in the study by Yogarajah et al. (35%) [8]. This difference may be due to a relatively lower diagnostic yield of outpatient EEG because outpatient EEG is usually short (20 min) and does not routinely incorporate sleep recording. Therefore, IEDs, including their spatiotemporal characteristics, are less likely to be recorded.

A great part of the diagnostic yield of VEEG is attributable to the differentiation between NEEs and epilepsy. In all patients who were confirmed to have NEEs, typical events were recorded without an epileptic EEG change in addition to the absence of IEDs. The diagnosis of NEEs can be difficult. One study found that epileptologists rarely missed epileptic seizures in temporal lobe epilepsy but often overdiagnosed NEEs as epileptic seizures [12]. This agrees with our finding that no patient with epilepsy was misdiagnosed with NEEs before admission, but 17 patients (9.4% of all the patients admitted for diagnostic clarification) who were previously misdiagnosed as having epilepsy were found to have NEEs after VEEG. Hence, VEEG was very helpful in diagnosing NEEs. The number of patients diagnosed with NEEs increased from 31 (10.4%) on admission to 88 (29.5%) on discharge, while the number of patients diagnosed with epilepsy (including all its subtypes) only increased from 193 (64.8%) on admission to 197 (66.1%) on discharge. Similarly, other studies showed that the percentage of patients diagnosed with NEEs on discharge markedly increased up to 39%–30.5% compared with that of patients diagnosed with NEEs on admission [7,8].

There were 16 patients diagnosed with PNESs on discharge, of whom 10 patients had been previously misdiagnosed with epilepsy. The median time of diagnosis delay for these patients was 72.3 months (range = 2 days to 17 years), which is similar to the results of another study [13]. Adequately recording typical events is the key factor in diagnosis. In our study, typical events were recorded in about one-half of the patients, and VEEG provided useful diagnostic information in 76.5% of our patients. For patients who have no typical clinical events recorded, they were diagnosed as epilepsy when typical interictal epileptiform discharges were recorded or were further classified as focal/generalized epilepsy by the typical distribution of discharges. The diagnostic yield of inpatient VEEG in our center is close to that reported in developed countries [7,8].

Our study has several limitations. First, the study was conducted at a local center, and the results may not be representative for all regions of China. Second, it did not include a long-term follow-up; thus, the utility of the diagnostic change could not be fully assessed. Third, the cohort observed mainly comprised adults. Finally, a relatively low percentage of generalized epilepsy was found; therefore, the data may not be representative of the patient population with generalized epilepsy.

5. Conclusions

Despite these limitations, our study indicates that VEEG provides useful diagnostic information for differentiating between focal epilepsy and generalized epilepsy, distinguishing NEEs from epilepsy, and identifying unrecognized seizures and seizure types. In our cohort study, VEEG of a relatively short duration produced a comparable diagnostic yield with the yield reported in other studies.

Conflict of interest statement

None of the authors have any conflict of interest to disclose.

Acknowledgments

None.

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