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Retrospective Analysis of Patients Undergoing Video-EEG Monitoring

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Abstract

Objective: Video-electroencephalography (EEG) monitoring (VEM) is an essential tool in diagnosing and treating epilepsy as it enables real-time monitoring and recording of electrical activity in the brain. We investigated the role of VEM in the diagnosis and treatment of epilepsy and recurrent paroxysmal events.

Methods: We retrospectively examined patients monitored in our VEM unit between 2008-2016. We registered demographic and clinical information from the patients' files. The VEM was performed until at least three typical seizures were recorded or the predetermined recording period ended. An experienced neurologist reviewed and interpreted all video-EEG recordings and compared them to the initial diagnoses. Any changes in the diagnoses and treatment plans were recorded.

Results: A total of 252 patients were included in this study. VEM was performed for pre-surgical planning or vagal nerve stimulation in 170 (67.46%), diagnosis/differantial diagnosis in 54 (21.42%), seizure classification in 18 (7.14%), and treatment follow-up in 10 patients (3.96%). A total of 187 patients (74.2%) had seizures [11 of whom had both epileptic seizures and psychogenic non-epileptic seizures (PNES)], 14 (5.55%) had only PNES, and one (0.39%) had a sleep attack due to idiopathic hypersomnia. VEM provided an additional contribution in diagnosis in 197 patients (78.17%). Diagnosis and management were changed in 26 (10.31%) and 175 patients (69.16%), respectively, following VEM.

Conclusion: VEM plays a crucial role in the diagnosis and management of epilepsy, particularly when used in presurgical planning. In additionally, VEM, the gold standard in diagnosing PNES, may change the diagnosis, especially in patients with PNES or PNES plus epilepsy.

Keywords: Epilepsy, diagnosis, video-electroencephalography, video-EEG monitoring

INTRODUCTION

Video-electroencephalography (EEG) monitoring (VEM) is an indispensable part of daily epilepsy practice, as it allows for real-time monitoring and recording of electrical activity in the brain. VEM can be used to distinguish between epilepsy and other paroxysmal events, such as psychogenic non-epileptic seizures (PNES), and to define the seizure type and determine the seizure onset zone before epilepsy surgery.[1,2] Furthermore, VEM can provide long-term investigation of continuous spike-wave discharges in Landau-Kleffner syndrome and electrical status epilepticus during sleep.[1]

Continuous VEM can also show the duration and frequency of ictal activity, making it a useful tool for the treatment follow-up. In some cases, VEM may even reveal different seizure types than those determined by anamnesis and interictal EEG, potentially changing diagnosis.[3]

In this study, we investigate the contribution of VEM in the diagnosis and treatment of patients with epilepsy, along with its ability to change the primary diagnosis before VEM and the treatment approach.

METHODS

Patient Population

We retrospectively investigated the patients who were monitorized in the Cerrahpaşa Faculty of Medicine Faculty, Department of Neurology, VEM unit between 2008-2016. The İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, Institutional Ethical

Committee approved the study (no: A-18, date: 07.03.2017), and the need for informed consent was waived by the ethics committee. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. We registered relevant information from patient files: Demographic features, clinical semiology, age of seizure onset, seizure frequency, anti-seizure drugs (ASD), neurological examination findings, a history of febrile seizures or other disorders, history of familial epilepsy, prior EEG, brain magnetic resonance imaging (MRI), and ^{18}F-fluorodeoxyglucose positron emission tomography (^{18}F-FDG PET) findings.

Seizure types of patients were classified according to the International League Against Epilepsy (ILAE) classification in 2017.[4]

Video-EEG Monitoring Procedure

The VEM recordings were performed using scalp electrodes following the international 10-20 electrode montage system.[5] Scalp electrodes were placed using a collodion, and sphenoidal or anterior temporal electrodes were placed if necessary. The data were digitally recorded using 16-32 channel referential, longitudinal, and transversal bipolar montages. Additionally, a continuous high-resolution video recording was performed during the VEM. Spikes, sharp waves, spike and wave complexes, and temporal intermittent rhythmic delta activity were considered epileptiform activity, and continuous focal slow wave activity was also determined.[6]

To confirm that the seizures or attacks detected during the recording were similar to habitual ones, and to report behavioral changes and seizures during the patient hospitalization, a companion accompanied the patients and pressed the alarm button when necessary.

As activation methods, intermittent photic stimulation and hyperventilation were performed in all patients. ASDs were reduced or discontinued to facilitate the onset of seizures, and were continued at the same doses after the proper seizure recording. VEM was continued until at least three habitual seizures of the patient were recorded or until the planned duration of recording ended. EEG technicians constantly monitored patients for possible status epilepticus, and all necessary equipment for intervention was kept in an easily accessible area.

All EEG recordings were reviewed and interpreted by an experienced neurologist, and the results were compared with the clinical presentation and previous EEG findings. The VEM recording time, number of seizures observed, ictal and interictal EEG findings, and both the preliminary and final diagnoses were noted.

Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences software (version 24.0), and the data were presented as mean±standard deviation or percentage. A p value less than 0.05 was considered statistically significant.

RESULTS

Patient Characteristics

A total of 252 patients were included in this study. There were 130 females (51.58%) and 122 males (48.41%). While the mean age of the patients was 32.75±10.1 years (ranging from 13-65 years), mean age of seizure onset was 13.1±9.93 years (ranging from 1 month-59 years). Mean VEM duration was 3.2±1.8 days (ranging from 1-9 days). Five patients (1.98%) had daily, 121 patients (48.01%) had weekly, 61 patients (24.2%) had monthly, and 11 patients (4.36%) had annually seizures, and 54 (21.42%) patients did not have recurrent seizures at the time of the recording.

The reason for VEM was as follows: i) evaluation of drug-resistant epilepsy before epilepsy surgery or vagal nerve stimulation (VNS) in 170 (67.46%), ii) for diagnosis or differential diagnosis in 54 (21.42%), iii) seizure classification in 18 (7.14%), and iv) treatment follow-up in 10 (3.96%).

Various neurological examination findings were detected in 36 patients (14.28%). Additionally, intellegence was normal in 192 (76.19%), there was mental retardation in 55 (21.82%), and there were no data regarding intellegence in 5 (1.98%).

While 225 patients (89.28%) had more than 2 or more ASDs and 23 patiens (9.12%) had one ASD, the remaining 4 patients (1.58%) were drug-free. Six patients (2.38%) had prior epilepsy surgery, and three (1.19%) had VNS. Fifty-nine patients (23.41%) had a psychopathology and 54 received (21.42%) antipsychotic drugs.

Past history revealed that 167 patients (66.26%) had a history of febrile convulsions and 10 patients (4.36%) had a history of CNS operation due to abscess, tumor or cavernoma. A total of 180 patients (71.42%) had a family epilepsy history.

Cranial MRI findings are given in Table 1. ^{18}F-FDG PET was performed in 141 patients (56.34%). Focal hypometabolism was

Table 1. Cranial MRI findings

Cranial MRI findings	Patients, n (%)
Mesial temporal sclerosis	98 (38.88)
- Mesial temporal sclerosis	71 (28.17)
- Probable mesial temporal sclerosis	19 (7.53)
- Dual pathology	8 (3.17)
Gliosis	39 (15.47)
Focal cortical dysplasia	13 (5.15)
Other malformations of cortical development	10 (3.96)
- Polymicrogyria	3 (1.19)
- Heterotopia	3 (1.19)
- Schizencephaly	1 (0.39)
- More than one malformations of cortical development	3 (1.19)
Tumour	6 (2.38)
- Dysembryoplastic neuroepithelial tumor	2 (0.79)
- Ganglioglioma	1 (0.39)
- Other	3 (1.19)
Other pathologies	26 (10.31)
Normal	60 (23.8)
Total	252 (100)

MRI: Magnetic resonance imaging

detected in 123 of 142 patients (86.61%) who underwent interictal PET examination, whereas PET examination was normal in 19 of them (13.38%).

Interictal EEG findings before VEM are given in Table 2 in detail.

Interictal and Ictal Findings of Video-EEG Monitoring

Interictal EEG was normal in 43 patients (17.06%). There was a focal epileptiform activity in 186 (73.8%), slowing of background activity in 15 (5.95%), and generalized epileptiform activity in 8 (3.17%).

A total of 187 patients (74.2%) had a seizure recording during VEM. When patients who had an ictal record were evaluated all together, seizures could be localized in 90 (48.12%), and lateralized in 34 patients (18.18%). The rest of 63 patients (33.68%) were as follows: 57 (30.48%) non localised/lateralized/no ictal activity, 6 patients (3.2%) generalized onset epilepsy/epileptic encephalopathy.

Among epilepsy surgery candidates (n=170), 160 had seizures during VEM. Ictal activity was localized in 78 (48.75%) and lateralized in 29 (18.12%). In the remaining 53 patients (33.12), ictal EEG was normal/non-localized or there was a generalized onset ictal pattern.

Seizure Characteristics on Video-EEG Monitoring

Among 252 patients, 187 patients (74.2%) had seizures. While forty-two patients (22.45%) had one seizure, 145 (77.54%) had two or more seizures. Seizure types are given in Table 3. Additionally, 14 patients (5.55%) had only PNES, 11 (4.36%) had both epileptic seizures and PNES, and one patient (0.39%) had sleep attack (idiopathic hypersomnia). None of the patients experienced serious adverse events such as severe injury or status epilepticus.

What Changed After Video-EEG Monitoring

Before VEM, there were 67 patients with normal EEG findings and 42 patients with only slowing of background activity in interictal EEG. Among these 109 patients, 43 (39.44%) showed interictal epileptiform findings on VEM.

MAIN POINTS

- Video-electroencephalography (EEG) monitoring (VEM) plays a crucial role in the diagnosis and management of epilepsy.
- The contribution of VEM in diagnosis and treatment is higher in presurgical planning compared to other indications.
- Video-EEG might change the diagnosis, especially in patients with psychogenic non-epileptic seizures.

Table 2. Interictal EEG findings before video-EEG monitoring

Interictal EEG findings	Patients, n (%)
Normal	67 (26.58)
Background slowing	42 (16.66)
Epileptiform activity	143 (56.74)
- Focal	124 (49.2)
- Generalized	19 (7.53)
Total	252 (100)

EEG: Electroencephalography

During VEM, out of all patients, 187 patients (74.2%) had seizures (11 of whom had both epileptic seizures and PNES), 14 (5.55%) had only PNES, and one (0.39%) had a sleep attack due to idiopathic hypersomnia. In five patients with seizures, it was impossible to make a judgment about the origin or type of seizures. The remaining 50 patients (19.84%) did not experience any attack. Therefore, overall, VEM provided an additional contribution to 197 patients (78.17%). Interestingly, two patients with a diagnosis of drug-resistant focal epilepsy were diagnosed with generalized onset epilepsy after VEM. Among all patients, the diagnosis was changed in 26 (10.31%) after VEM.

In the epilepsy surgery group, there were 170 patients. Their mean age at seizure onset was 11.8±6.5 years (ranging from one month to 59 years) and the mean VEM duration was 3.53±1.7 days (ranging from one day to one week). Although 160 patients experienced at least one seizure, the seizure-onset zone remained undiagnosed in three of them. Overall, VEM made an additional contribution in handling 157 patients (92.35%) who were monitored for epilepsy surgery. Interestingly, the diagnosis changed from epilepsy to epilepsy plus PNES in one patient (0.58%) in this group. Overall, a desicion for resective surgery was made in 72 patients (28.57%), but 64 had surgery, eight patients refused. Fifty patients who underwent resective surgery achieved seizure-free status (78.12%). Further diagnostic tests (^{18}F-FDG PET, single-photon emission computed tomography, neuropsychological evaluation), and invasive monitoring were planned in 60 patients (23.8%). At the time of the study, nine patients underwent VNS, and in one of them (11.11%), the seizure frequency decreased by about 50%. Moreover, 17 patients underwent resective surgery following invasive monitoring, and five of them (29.41%) became seizure-free.

In the diagnosis/differential diagnosis group, there were 54 patients. Final diagnoses were as follows: PNES in 14 (25.92%), epilepsy in 12 (22.22%), epilepsy plus PNES in 10 (18.51%), and hypersomnia in one (1.85%). Fourteen patients (25.92%) did not experience any paroxysmal event, and 3 (5.55%) remained undiagnosed despite the recorded attacks. Overall, VEM provided a support to diagnose in 37 of 54 patients (68.51%). Additionally, the diagnosis changed

Table 3. Recorded seizure types in video-EEG monitoring

Seizure type	Patients, n (%)
Focal onset, impaired awareness	100 (53.47)
Focal to bilateral tonic clonic	38 (20.32)
Focal onset, preserved awareness	18 (9.62)
Focal onset, unknown awareness status	16 (8.55)
- Tonic	8 (4.27)
- Hypermotor	6 (3.2)
- Gelastic seizures	2 (1.06)
Generalized onset seizures	7 (3.74)
- Atypical absence	3 (1.6)
- Tonic-clonic	2 (1.06)
- Tonic	1 (0.53)
- Myoclonic	1 (0.53)
Focal and generalized onset seizures	5 (2.67)
Remained undiagnosed	3 (1.6)
Total	187 (100)

EEG: Electroencephalography

in 23 of 54 patients (42.59%), with the change being from epilepsy to purely PNES in 12 patients, from epilepsy to epilepsy plus PNES in 10 patients, and from epilepsy to hypersomnia in one patient. The mean diagnostic gap before the diagnosis of PNES was found to be 4.9±2.1 years. The mean duration of VEM in patients with PNES was 0.8±1.3 days, which was shorter compared to the total group. Twelve of the 14 patients (85.71%) with purely PNES had previously been diagnosed with epilepsy and had been prescribed at least one ASD before VEM. The ASDs used by these patients were discontinued and they were referred to psychiatry.

In the seizure classification group (n=18), the following diagnosis was made: focal onset epilepsy in 3 (16.66%), generalized onset epilepsy in 2 (11.11%), and epileptic encephalopathy in 4 (22.22%). The remaining 9 patients (50%) did not experience any paroxysmal event. Overall, VEM did an additional contribution to seizure classification in 50%. One patient (5.55%) underwent VNS, further diagnostic tests were planned in one (5.55%), and the management did not change in 16 (88.88%).

Out of the ten patients who were monitored for treatment follow-up, only two (20%) had seizures with a localized ictal pattern. There was no change in the diagnosis and treatment approach in this group of patients.

Ten patients (3.96%) were lost during follow-up, and management did not change in 67 patients (26.58%). Overall, the management changed after VEM in 175 patients (69.16%). Procedures performed after VEM are given in detail in Table 4.

DISCUSSION

The major findings of our study were: i) VEM provided an additional contribution to the diagnosis in 78% of patients, ii) VEM changed diagnosis in 10% of patients, and, iii) the treatment changed in 69% of patients after VEM. It is worth noting that previous studies have mainly examined the short-term outcomes of patients who were monitored in VEM units, ranging from six months to six years.[3,7-16] Our study provided long-term results of VEM as it included patients who were monitored for a period of 8 years. Additionally, our study mainly included patients who were evaluated for presurgical evaluation, and it evaluated the contribution of VEM for treating drug-resistant epilepsy, which is different from the focus of existing studies in this field.[7,10,12,14,15,17]

Table 4. Procedures performed after video-EEG monitoring

Procedure	Patients, n (%)
Desicion for resective surgery	72 (28.57)
- Surgery performed	64 (25.39)
- Refusing the surgery	8 (3.17)
No change in management	67 (26.58)
Invasive monitoring	35 (13.88)
Referral to psychiatry	30 (11.9)
Additional tests needed/not yet finalised at the time of this study	25 (9.92)
Vagus nerve stimulation	11 (4.36)
Lost to follow-up	10 (3.96)
Corpus callosotomy	2 (0.79)
Total	252 (100)

EEG: Electroencephalography

VEM provides essential information in patients with recurrent paroxysmal events via a simultaneous recording of brain bioelectrical activity and video recording.[1,15] VEM can be used for various purposes, such as diagnosing epilepsy, seizures classification, planning surgery for refractory epilepsy, identifying non-epileptic paroxysmal events, and monitoring treatment for epilepsy.[1,7,10,15] The diagnostic contribution of VEM ranges from 61% to 88%.[3,12,14,18] Consistently, VEM contributed to the diagnosis of 78% of the patients in our study. The duration of VEM in our study was 3.2±1.8 days, which is concordant with previous reports.[15,17] Since approximately 3-4 days of recording can provide solutions to many unanswered questions in a particular patient, any patient with intractable, recurrent paroxysmal events should be given the chance for VEM.

The use of VEM was found to be more effective in the diagnosis and treatment of epilepsy surgery cases, as opposed to its use in cases of diagnosis/differential diagnosis, seizure classification, and treatment follow-up. Although there is a lack of data comparing the effectiveness of VEM in different medical indications, Alving and Beniczky[10] found that VEM is more beneficial in pre-surgery cases than in cases involving diagnosis or seizure classification.

Previous studies have shown that the utility of VEM in changing the diagnosis ranges from 6% to 60%, and in changing treatment ranges from 19% to 73%.[3,7,12,13,17] In our study, the diagnosis was changed in around 10% of patients. The most common change was from epilepsy to pure PNES or epilepsy to epilepsy plus PNES, as reported in literature.[3,7,13]

Additionally, different studies have reported that the ratio of pure PNES diagnosis after VEM ranged from 4% to 30%.[3,8,13,15,18,19] Benbadis et al.[20] found that roughly one-quarter of patients diagnosed refractory epilepsy and sent for VEM had PNES, not epilepsy. Our diagnostic change ratio and pure PNES ratio were lower than in studies that excluded patients who were monitored for epilepsy surgery.[3,15,19] This is because patients who are candidates for epilepsy surgery undergo extensive investigation before VEM, which reduces the likelihood of diagnostic change. Additionally, we have an additional video EEG monitoring unit in our department, which is used for shorter recordings within the limits of a working day and which is mostly preserved for patients with probable PNES. Patients with PNES need a shorter monitorization period, as shown in this study and in some others, so such a daily unit may be sufficient for most of these patients.[3,14,15,19]

ILAE considers that the diagnostic delay of PNES is around three years.[21] However, Volbers et al.[22] showed that this time could be around seven years. In our study population, the mean diagnostic gap was 4.9 years. The diagnostic gap can be shortened after the widespread use of VEM in patients with PNES. Collaboration with psychiatry during VEM may be another benefit of VEM because psychiatrists worldwide, who stay away from patients with PNES, seem to contribute to wrong epilepsy diagnosis in this patient population.[23] This situation could lead to severe consequences, such as misdiagnosis of refractory epilepsy, prescription of unnecessary medications, and even invasive procedures, all of

which can impede the timely initiation of appropriate psychiatric treatment.[21,24] VEM is the gold standard for diagnosing PNES and avoiding such situations.[19,21]

In our study, the treatment plan for 69% of patients changed after VEM, which is consistent with previous research.[7,13] As expected, most of these changes occurred in the group of patients undergoing epilepsy surgery. Resective surgery was performed in 64 patients (25.39%), and 78% of them remained seizure-free. Unfortunately, in some regions, few patients with drug-resistant epilepsy who could benefit from VEM may not have access to it due to a limited number of VEM units.[25] It is important to not only increase the availability of VEM units, but also to raise awareness of drug-resistant epilepsy and ensure that patients with this condition are referred for VEM in a timely manner. This can help improve the diagnosis and treatment options for these patients.

Study Limitations

This study has some limitations that should be taken into consideration. First, since it is a single-center study, the findings may not be representative of other centers' clinical practices. Second, the retrospective design of the study may have led to a selection bias as patients with insufficient medical records were excluded. Third, since most of our patients were monitored for presurgical planning, and all of them underwent extensive investigation before VEM, the rate of diagnostic changes and new diagnoses could be lower than it actually is, which may limit the generalizability of the results.

CONCLUSION

VEM has a significant impact on the diagnosis and management of patients with recurrent paroxysmal events. The contribution of VEM in diagnosis and treatment is higher in presurgical planning compared to other indications. In our study, VEM changed diagnosis for 10% of patients and a change in treatment in 69% of patients. In addition, more than 75% of patients who underwent resective surgery following VEM remain seizure-free. Furthermore, VEM, the gold standard in diagnosing PNES, might change the diagnosis, especially in patients with PNES or PNES plus epilepsy.

Ethics

Ethics Committee Approval: The İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, Institutional Ethical Committee approved the study (no: A-18, date: 07.03.2017).

Informed Consent: Retrospective study.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: A.M., C.A., Ş.D., T.T., S.N.Y., Design: A.M., C.A., Ş.D., T.T., S.N.Y., Data Collection or Processing: A.M., C.A., Ş.D., T.T., S.N.Y., Analysis or Interpretation: A.M., C.A., Ş.D., T.T., S.N.Y., Literature Search: A.M., C.A., Writing: A.M., C.A., Ş.D., S.N.Y.

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