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# A Comparision of Video EEG Monitoring and Routine EEG for Diagnosis of Epilepsy

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**Abstract**

**Objective:** The aim of this study was to investigate the diagnostic utility of routine electroencephalogram and video electroencephalogram monitoring.
**Methods:** We performed a retrospective analysis on patients admitted to our video electroencephalogram monitoring unit. The yield of routiene electroencephalogram and video electroencephalogram monitoring was compared and assessed with the detection of epileptiform discharges.
**Results:** Out of 191 patients, the epileptiform discharges found in routiene electroencephalogram and video electroencephalogram monitoring were 39 (21%) and 99 (52%), respectively. The yield of epileptiform discharges differed significantly between video electroencephalogram monitoring and routiene electroencephalogram ($P < .001$). While the epileptiform discharges detection rate (95% CI) was 0.29 (0.25-0.46) for routiene electroencephalogram, it was 0.93 (0.86-0.97) for video electroencephalogram monitoring.
**Conclusion:** Compared to routiene electroencephalogram, video electroencephalogram monitoring is superior in detecting epileptiform discharges.
**Keywords:** EEG, video EEG monitoring, epilepsy, epileptiform discharges

## INTRODUCTION

Epilepsy is a clinical diagnosis based on the history given by the patient or witnesses. Sometimes it may be unavailable or insufficient, thus diagnosis remains uncertain.[1] Therefore, diagnosing and classifying accurately requires careful evaluation of neuroradiological imaging, clinical semiology, and electroencephalogram (EEG) along with the seizure history. The presence of interictal epileptiform discharges (IEDs) is very helpful for an epilepsy diagnosis. The fact that EEG is such a valuable diagnosing method in diagnosing epilepsy makes routine EEG (rEEG) a common diagnostic method with its ease of access, short interpretation time, and low cost. However, routine wakefulness EEG may be insufficient to differentiate epileptic seizures from nonepileptic seizures and to classify epileptic seizures. Therefore, long-term video EEG monitoring (VEM) plays a considerable role in understanding and making a differential diagnosis of epilepsy syndrome. Displaying video and EEG simultaneously provides a diagnostic advantage in epileptic and nonepileptic disorders as well as long-term interictal EEG recording.[2] Along with EEG, other physiological monitoring facilities like continuous ECG can be useful to show the nature of nonepileptic events. Along with electroclinical correlation, VEM is the most appropriate diagnostic method, particularly in treatment optimization of the patients with drug-resistant epilepsy.[3] The duration of inpatient VEM may vary depending on the purpose of the session and the facilities of the center. While it may take days in presurgical evaluation, very short periods may be sufficient while identifying psychogenic nonepileptic seizures. The current study investigated the diagnostic utility of rEEG and VEM by assessing the yield of rEEG and VEM.

## METHODS

A retrospective analysis was performed on 250 consecutive patients admitted to the epilepsy monitoring unit in University of Health Sciences, Bakirkoy Prof. Dr. Mazhar Osman Training and Research Hospital for Psychiatry, Neurology and Neurosurgery, Neurology Department between September 2018 and March 2020. The medical records of all patients were rewieved. One hundred ninety-one patients who had rEEG prior to VEM were included. Along with VEM, clinical and sociodemographic features and the use of antiepileptic drugs (AEDs) were documented. Video EEG monitoring was applied to patients with a previous diagnosis of epilepsy due to acute exacerbations under antiepileptic therapy and to patients without epileptiform anomaly in their rEEG but clinically suspected to have epilepsy. Since some of the patients were referred directly to our video EEG unit, neuroradiological imaging and detailed information regarding seizure history were not available at the time of monitoring. The period between routine EEG and VEM performed in most cases was close, but in some cases, it was more than a year. An abnormal (positive) EEG was defined as the presence of epileptiform discharges. The epileptiform discharges were divided in 2 groups: focal and generalized. Focal abnormalities were divided into the following subgroups: bilaterally asynchronous epileptiform *discharges*, bilaterally synchronous epileptiform *discharges*,

and *lateralized epileptiform discharges*. The classification of patients diagnosed with epilepsy was determined by brain magnetic resonance imaging (MRI), current as well as past EEG, and clinical seizure type according to The International League Against Epilepsy (ILAE) 2017 classification. Seizure type was based on the seizure-related descriptions of the patient or of an eyewitness or video analysis. Video analysis was either ictal recording from past VEM or eyewitness video recording via smartphone. The patients who had more than one rEEG were detected and the last rEEGs performed prior to VEM were considered. The rEEG performed for each patient lasted 20 minutes and was performed during wakefulness. None of patients were sleep-deprived prior to rEEG. In line with the protocols of our unit, the duration of monitoring were standardized as 3 or 8 hours with sleep deprivation. Therefore, the monitoring of the patients admitted to our unit lasted 3 or 8 hours according to the request of their neurologists. The patients were asked to restrict their sleep prior to monitoring, and each VEM included at least 20 minutes of wakefulness EEG recording. A high-definition video camera was used in all recordings. All EEGs were performed using the international 10-20 system for electrode placement, including bipolar montages with longitudinal and transverse chains. Single-channel ECG was also recorded and displayed on the monitor along with EEG. All examinations included eye opening and closing, photic stimulation, and hyperventilation as activation methods.

The outcome was evaluated by the following measures:

1. The yields of rEEG and VEM;
2. The detection rate of rEEG (with 95% CI) was defined by the formula: yield of rEEG/yield of both rEEG and VEM (the number of all patients who had IEDs regardless of EEG type); and
3. The detection rate of VEM (with 95% CI) was defined by the formula: yield of rEEG/yield of both rEEG and VEM.

Statistical analysis was performed using Statistical Package for the Social Sciences software version 20.0 (IBM SPSS Corp.; Armonk, NY, USA). The variables were expressed as the mean and standard deviation (SD) or as percentages. For binary dependent variables, McNemar's chi-square test was used. Statistical significance was set at $P$ value of .05.

This study was approved by the Ethics Committee of Health Science University, Bakırköy Dr. Sadi Konuk Training and Research Hospital (Date: March 1, 2021, Decision No: 2021/109). All patients who participated in this study signed the informed consent.

## RESULTS

Fifty-nine out of 250 patients were excluded since their rEEGs were not available. A total of 191 patients were evaluated. There were 92 males and 99 females. The age range was 11-85 years (mean age ± SD, 39.17 ± 17.02 years). At the time of rEEG and VEM, 101and 119 patients, respectively, were on AED ranging from monotherapy to polytherapy with 4 drugs (Table 1). Of these, 66 patients were on same AED at the same dose during rEEG and VEM. A total of 6 and 3 patients, respectively, had dose increase and decrease on same AED, 6 had AED change between monotherapies, 11 had changed from monotherapy to polytherapy or vice versa, 21 were not on any AED during rEEG but were on monotherapy or polytherapy during VEM, 2 had been on monotherapy during rEEG but stopped taking AED by their own decision, so they were not under medication at the time of VEM. There were some differences in AEDs between the 2 studies of 6 patients who were under polytherapy during both rEEG and VEM.

All rEEGs were performed during wakefulness. Thirty-nine out of 191 patients (20%) showed abnormal rEEGs revealing IEDs; of these, 31 patients had abnormal VEM congruent with interictal rEEG findings and 8 patients had normal VEM. Out of 99 patients who had abnormal VEM, 68 had normal rEEG (Table 2). In the remaining (48%) patients, both studies were normal.

The yield of rEEG was 20% (39 out of 191 patients); of these, 30 patients had focal IEDs and 9 had generalized IEDs. Of patients with previously normal rEEGs, 69 showed an IED on their VEM. The yield of VEM was 52% (99 out of 191 patients). Of these, focal IEDs were detected in 80 patients and generalized IEDs were detected in 19 patients. All epileptiform discharges captured differed significantly between VEM and rEEG ($P < .001$).

While the detection rate of epileptiform discharges of rEEG was 0.29 (95% CI 0.25-0.46), it was 0.93 (95% CI 0.86-0.97) for VEM. The detection rate of focal discharges of VEM was 0.93 (95% CI 0.86-0.97) and rate of abnormalities of generalized discharges of VEM was 0.90 (95% CI 0.70-0.99) (Table 3). In the overall cohort, 142 patients were diagnosed with epilepsy. The number of patients with focal onset seizure were 103, generalized onset were 23, and unknown onset were 16. Of these, 118 patients were diagnosed with epilepsy prior to VEM. The remaining 24 patients were diagnosed with epilepsy following the VEM. About 70% of patients (99 out of 142 patients) who went on to be diagnosed with epilepsy had IEDs on VEM. Of these, 69 patients had epileptiform discharges during sleep, 12 during wakefulness, and the remaining 18 patients had epileptiform discharges during both sleep and wakefulness. Interictal epileptiform discharges were higher in sleep.

Out of 30 patients who had focal epileptiform discharge on rEEG, 5 patients had bilaterally asynchronous epileptiform discharges, 2 patients had bilaterally synchronous epileptiform discharges, and 23 patients had lateralized epileptiform discharges. Generalized epileptiform discharges were seen in 9 patients. Out of 80 patients with focal epileptiform discharges on VEM, bilaterally asynchronous epileptiform discharges and bilaterally synchronous epileptiform discharges were found in, respectively, 4 and 11 patients. Lateralized epileptiform discharges were found in 65 patients. Lateralized epileptiform activity was the most common abnormality in both studies (Table 4).

**Table 1.** Demographic Data

| | |
|---|---|
| Number of cases | 250 |
| Number of cases excluded | 59 |
| Number of cases included | 191 |
| Age range (mean ± SD) | 11-85 (39.17 ± 17.02) |
| Number of males, n (%) | 92 (48%) |
| Number of females, n (%) | 99 (52%) |
| Number of patients on AEDs, n (%) | |
| rEEG | |
| Monotherapy | 79 (41%) |
| Polytherapy | 22 (12%) |
| Total | 101(53%) |
| VEM | |
| Monotherapy | 92(48%) |
| Polytherapy | 27 (14%) |
| Total | 119 (62%) |

AEDs, antiepileptic drugs; rEEG, routiene electroencephalogram; VEM, video electroencephalogram monitoring.

**Table 2.** Epileptiform Discharges on Routine EEG and Video EEG Monitoring

| Epileptiform Discharges on rEEG | Epileptiform Discharges on VEM | Patient (n) | Total Patient (n) |
|---|---|---|---|
| No | No | 84 (44%) | 84 (44%) |
| No | **Yes** | 68 (37%) | 107 (56%) |
| Yes | No | 8 (4%) | |
| Yes | **Yes** | 31 (16%) | Focal: 86 Gen: 21 |

Gen, generalized; rEEG, routiene electroencephalogram; VEM, video electroencephalogram monitoring.

The duration of VEM in 141 patients (%74) was 3 hours, and in 50 patients (26%), it was 8 hours (mean 4.3 hours). The number of patients with epilepsy who applied for 3-hour VEM and 8-hour VEM was 82 and 41, respectively. There was no statistically significant difference ($P$ = .1). Of 141 and of 50 patients who underwent -3 and 8 hour-VEM, respectively, 68 (48%) and 31 (62%) had epileptiform discharges. In the analysis of the effect of duration of the session on epileptiform discharges detection, no statistically significant difference was found between 3-hour VEM and 8-hour VEM ($P$ > .05).

## DISCUSSION

The value of rEEG in diagnosing epilepsy is indisputable, however, the occurrence of epileptiform discharges on the first routine EEG in epileptic patients is only about 38-55%.[4] This study investigated by capturing epileptiform activity on both rEEG and VEM in a cohort with a view to make a differential diagnosis of suspected seizures and patients diagnosed with epilepsy prior to VEM.

Our population consisted of main adults. Among 191 patients, 39 patients had epileptiform discharges on rEEG with a yield of 21% which was lower than the 27-55% yield reported by the other studies.[5,6] However, compared to the other studies conducted with a cohort of patients diagnosed with epilepsy[7] and single unprovoked seizure,[8] the probable reason for the lower yields of the current study is due to the mixture of patients diagnosed with epilepsy and suspected patients.

In the literature, the rates of VEM capturing interictal discharges differ. Although there are studies detecting the presence of interictal discharge at a rate of 50-58%,[5,9] there are also studies that suggest a detection rate of 66-86%.[10,11] In our study, epileptiform activity was detected in VEM in 52% of the patients, and this value was partially compatible with the literature. The fact that the monitoring period is shorter than some studies suggests that this value may be related to the low duration. It also suggests that this result may be related to the difficulty in differential diagnosis due to the intensity of the outpatient clinics, short visit periods in our country, and the more use of EEG support.

Video EEG monitoring had a higher yield than rEEG for both focal and generalized epileptiform discharges, as in the overall discharges. The yield of epileptiform discharges differed significantly between VEM and rEEG recording ($P$ < .001). When compared to rEEG, VEM provides more benefits in diagnosing epilepsy. There are some possible explanations as to VEM is superior to rEEG in capturing epileptiform activity. During sleep, IEDs are more likely to occur. Both focal and generalized IEDs increase during non-rapid eye movement sleep,[12] In a study, it was shown that the yield of epileptic activity during sleep was significantly higher than that during photic stimulation or hyperventilation.[13] Performing EEG after sleep deprivation is another factor that facilitates the occurrence of IEDs[14] and thus capture IEDs on VEM. In this context, in patients with suspected epilepsy but no epileptiform discharges on rEEG, referring to VEM considerably provides benefit in diagnosing epilepsy.

Focal slowing on EEG can be nonspecific or an indicator of epileptogenic focus producing epileptiform discharges.[15] In this study, focal slowing was classified as a non-specific abnormality. Out of 9 patients with focal slowing and without epileptiform discharges on rEEG, 5 had lateralized epileptiform discharges on VEM in the ipsilateral hemisphere, 1 had bilaterally asynchronous epileptiform discharges, and 3 had focal slowing in the same region. Video EEG monitoring might be considered as a next step in the event of diagnostic uncertainty due to focal slowing on rEEG.

There are some studies that suggest that the duration of monitoring provides benefits in capturing epileptiform activity. However, no significant difference was found between 3- and 8-hour recordings in this study, with majority of 3-hour recordings ($P$ > .05).[11] It is thought that this situation may be related to the small sample size and the absence of a significant time between the compared durations.

Although the diagnosis of epilepsy for most patients in this study was accurate prior to the study, no patient had epileptic seizure during VEM. Even if recording habitual events with or without ictal discharge provides greater diagnostic information, typical seizures were

**Table 3.** The Yields and Detection Rates of Routine EEG and Video EEG Monitoring

| | Routine EEG (n = 191) | VEM (n = 191) | Detection Rate of rEEG (95% CI) | Detection Rate of VEM (95% CI) |
|---|---|---|---|---|
| Focal epileptiform discharges | 30 (16%) | 80 (42%) | 0.35 (0.25-0.46) | 0.93 (0.86-0.97) |
| Generalized epileptiform discharges | 9 (5%) | 19 (10%) | 0.43 (0.22-0.66) | 0.90 (0.70-0.99) |
| Epileptiform discharges | 39 (21% ) | 99 (52%) | 0.29 (0.20-0.38) | 0.93 (0.86-0.97) |

rEEG, routiene electroencephalogram; VEM, video electroencephalogram monitoring.

**Table 4.** The Subgroups of Epileptiform Discharges

| Epileptiform Discharges | rEEG | VEM |
|---|---|---|
| Bilaterally asynchronous epileptiform discharges | 5 (10.6%) | 4 (4%) |
| Bilaterally synchronous epileptiform discharges | 2 (%4.2) | 11 (11.1%) |
| Lateralized epileptiform discharges | 23 (48.9%) | 65 (65.6%) |
| Generalized epileptiform discharges | 9 (19.1%) | 19 (19.1%) |

rEEG, routiene electroencephalogram; VEM, video electroencephalogram monitoring.

not captured during VEM. In these patients, the detection of IEDs on EEG supports the diagnosis of epilepsy, whereas the absence of IEDs may raise a suspicion about the diagnosis of epilepsy.[11]

### Limitations

This study has several limitations. The lack of sufficient number of cases to evaluate the effect of duration of monitoring on capturing epileptiform discharges is a limitation. Repetitive rEEG results of the patients were not documented and compared. In addition, non-epileptiform seizures could not be evaluated since ictal records were not examined. Although some patients were known to have had seizures during the time period between rEEG and VEM, their seizures were not documented. The duration of the disease could not be documented because some of the patients, apart from those who had been followed for many years, were the first to apply and were recently diagnosed with epilepsy, some of them were referred to the video EEG unit from an external center.

## CONCLUSION

In conclusion, this study revealed that VEM lasting 3 hours and more is superior to rEEG in detecting focal and generalized epileptiform discharges, regardless of the exposure time. Although VEM has some disadvantages which lead to high cost such as requiring longer preparation time in technical terms, continuous nurse supervision, data storage, and costly equipments, misdiagnosis causing unnecessary drug therapies and multiple EEGs can lead to higher cost. Hence, it seems reasonable to refer VEM in order to prevent delay in diagnosis.

**Ethics Committee Approval:** This study approved by the Bakirkoy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (Date: March 1, 2021, Decision no: 2021-05-02, 2021/109).

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

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