

# Video electroencephalography monitoring differentiates between epileptic and non-epileptic seizures

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## ABSTRACT

**INTRODUCTION:** Epilepsy is often misdiagnosed and approximately one in every four patients diagnosed with refractory epilepsy does not have epilepsy, but instead non-epileptic seizures. Video electroencephalography monitoring (VEM) is the gold standard for differentiation between epileptic and non-epileptic seizures. The purpose of this study was to investigate the effectiveness of VEM as a diagnostic tool.

**MATERIAL AND METHODS:** In this retrospective study, we have investigated the diagnostic outcome of 155 in-patients undergoing VEM at Copenhagen University Hospital (Rigshospitalet) over a two-year period.

**RESULTS:** The study showed that VEM revealed a diagnosis in 80%. Epilepsy was diagnosed in 38% and epilepsy was rejected in 43% of cases. In the remaining 20% of cases, epilepsy could not be excluded. Among patients who were referred in antiepileptic drug treatment, 29% did not have epilepsy. The highest diagnostic yield was obtained when patients had seizures with ictal electroencephalography paroxysms during VEM.

**CONCLUSION:** Several patients without epilepsy are treated as if they had epilepsy. VEM is a costly method, but with a large diagnostic yield and should therefore be used when there is doubt about the diagnosis in patients with relatively frequent seizures. The use of VEM is expedient to make the correct diagnosis, optimize medical treatment of patients with epilepsy and to avoid unnecessary treatment in patients without epilepsy.

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A common clinical problem is whether a patient with seizures has epilepsy. Patients may present with epilepsy-like symptoms without having epilepsy and anti-epileptic drugs will have no effect. Epilepsy is diagnosed on the basis of a comprehensive assessment of medical history, clinical appearance, electroencephalography (EEG) and possibly magnetic resonance imaging (MRI). Patients with sudden episodes of epilepsy-like symptoms are frequently misdiagnosed as having epilepsy on the basis of insufficient clinical information. It is therefore important to document the clinical episodes in

order to distinguish between epileptic and non-epileptic seizures [1]. The diagnostic gold standard is long-term video-EEG monitoring (VEM). Studies show that 20-25% of all patients referred to VEM under the diagnosis of refractory epilepsy have non-epileptic seizures only [2].

This study evaluated the diagnostic value of VEM in patients under suspicion of having epilepsy. During VEM, video and EEG are recorded simultaneously to compare clinical and electrographic findings. The patient is admitted to the Epilepsy Monitoring Unit (EMU) typically for a 2-3 day period, with video surveillance and equipped with an electrode cap, electrocardiography and electromyography electrodes. The EMU at Copenhagen University Hospital (Rigshospitalet) has the capacity to treat four patients simultaneously. The majority of EMU patients are the diagnostic patients investigated herein, but approximately 30% are patients with extracranial or intracranial electrodes admitted for epilepsy surgery work-up.

EEG is a sensitive method for detection of paroxysmic activity during seizures. However, it will sometimes fail to detect paroxysmic abnormalities, particularly during simple focal seizures, and sometimes fails to detect complex partial seizures, especially if the focus is in the frontal lobes. Interictal paroxysms are detected frequently between seizures in epileptic patients, but are also seen in approx. 0.5% of healthy young people and even more frequently in patients with other neurological or psychiatric conditions. Thus, the diagnosis of epilepsy is clinical and it is based on an overall assessment of clinical symptoms, EEG and history [3].

VEM is a unique tool for visualizing the correlation between clinical symptoms and electroencephalographic signals and it is the gold standard for differentiation between epileptic and non-epileptic seizures [1]. This study aimed to examine the method's effectiveness as a diagnostic tool in diagnostic patients.

## MATERIAL AND METHODS

Patients seen at the Epilepsy Clinic, Rigshospitalet, are investigated with VEM if the diagnosis of epilepsy is found to be uncertain and the patient has at least one

## ORIGINAL ARTICLE

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 TABLE 1

Overview of the diagnostic category and electroencephalographic findings.

Concluding diagnosis	Seizures during VEM, n		
	yes, ictal paroxysms		no
	yes	no	no
Epilepsy	32	8	12
PNES		40	5
Epilepsy + PNES	2	3	1
Unresolved		9	22
Other		11	10
Total (n = 155)	34	71	50

PNES = patient with psychogenic non-epileptic seizures.  
VEM = video electroencephalography monitoring.

 TABLE 2

Number (and percentage) of patients in each antiepileptic drug treatment category by concluding diagnosis. One patient was excluded due to lack of information.

Concluding diagnosis	Treated with AED before VEM	
	yes	no
Epilepsy	47 (47)	4 (7)
PNES	20 (20)	25 (46)
Epilepsy + PNES	6 (6)	
Unresolved	18 (18)	13 (24)
Other	9 (9)	12 (22)
Total (n = 154)	100	54

AED = antiepileptic drugs; PNES = patient with psychogenic non-epileptic seizures; VEM = video electroencephalography monitoring.

seizure per month. The uncertainty of the diagnosis is based on seizure history, little or no effect of antiepileptic drugs (AED), and whether or not previous investigations have provided diagnostic clarification.

Charts and EEG descriptions of adult patients hospitalized for diagnostic VEM within the period from 1 January 2006 to 31 December 2007 were reviewed retrospectively. The charts provided general information about the patients, whether they were treated with AED before the monitoring and if subsequent modifications were made to the medication. From the EEG descriptions we recorded the number of seizures, the duration of the recording and presence of interictal and ictal paroxysmic activity.

Each patient was subsequently given a concluding diagnosis falling into one of the following five categories: "Epilepsy" (patient with unprovoked epileptic seizures), "PNES" (patients with only psychogenic non-epileptic seizures), "Epilepsy and PNES" (patients with both types of seizures), "Unresolved" (epilepsy could not be excluded) or "Other" (epilepsy and PNES were excluded). The patients in category "Other" were diagnosed with

syncope, migraine with aura, non-epileptic myoclonus, sleep apnoea, alcohol abuse, overuse of benzodiazepines or parasomnia.

*Trial registration:* not relevant.

## RESULTS

### Patient group

A total of 182 adult patients were admitted from the Department of Neurology for diagnostic VEM in the two-year period. Insufficient chart information caused the exclusion of 27 patients. Among the 155 included patients there were 165 admissions to the EMU, since eight patients were recorded twice and one patient was recorded three times. Female patients represented 65% of the cases. The average patient age was 39.7 years (range 15-86 years). Prior to admission, 100 patients (65%) were treated with AED. In one patient, information on AED treatment was lacking. During the monitoring sessions, 105 patients (68%) had a minimum of one seizure. On average 4.4 seizures were recorded per patient (range 0-113). Time to first seizure was 19.3 hours (range 2 min-111 hours) and duration of monitoring was 58.6 hours (range 15 min-162 hours). Among the 155 patients, 113 (73%) had an earlier EEG when referred to VEM. Fifty-two patients had a previous EEG showing paroxysms and in 71% of the cases this was verified during VEM. Sixty-one patients had no paroxysms at earlier EEGs, but during VEM, paroxysms were found in 38% of cases. Overall, we found a discrepancy between earlier EEGs and VEM in 34% of the cases. Unfortunately, there was no information about previous investigation with MRI before referral to VEM.

### Contribution of electroencephalography findings to the diagnosis

The diagnostic outcome of VEM depends to a large extent on two measures: 1) whether a seizure has occurred and 2) whether it is associated with ictal paroxysms, which can be seen in **Table 1**. It is demonstrated that the presence of seizures as well as ictal paroxysms allows for an unambiguous clinical diagnosis, while seizures without ictal paroxysms or lack of seizures lead to concluding diagnoses in any of the categories with a substantial fraction remaining unresolved.

In eight of the 31 unresolved patients, the interictal EEG revealed paroxysms. Two of these eight patients had seizures during monitoring, both without ictal paroxysms. Thus, 52% of the unresolved cases had neither seizures, ictal paroxysms nor interictal paroxysms and therefore did not benefit directly from the stay in the EMU. However, there is also an indirect effect of an EMU stay, i.e. the intensive observation leading among other things to adjustment of medication, which oc-

curred in 49% of all patients on AED and in 28% of the unresolved patients.

The relation between AED treatment at time of referral and concluding diagnosis is presented in **Table 2**.

The vast majority (93%) of patients who were diagnosed with epilepsy were already in AED treatment at the time of referral. Conversely, 20% of the patients in AED treatment turned out to have PNES and an additional 9% had other non-epileptic manifestations. Thus, 29% of the patients in AED treatment who were referred for VEM did not have epilepsy. Among the patients diagnosed as not having epilepsy (PNES and other), 44% received AED treatment at the time of referral. A little more than half of these patients (55%) were tapered off medication immediately after the VEM.

## DISCUSSION

Video EEG monitoring aided in achieving a concluding diagnosis in 80% of the patients, thus confirming our hypothesis that VEM is a useful diagnostic tool in patients with epilepsy-like symptoms. We have found that an unambiguous diagnosis was reached in 91% of the patients who had seizures during VEM, but only in 56% of those who did not have seizures. Thus, recording of seizures is important for a high diagnostic yield of VEM, which is in accordance with findings in the literature that the sensitivity and specificity of ictal EEG is higher than for interictal EEG [4].

Interictal discharges during VEM may also contribute to the outcome of the investigation just as interictal discharges are often the major finding in the 30-minute standard EEG. Due to the longer registration time in VEM, the chance of catching uncommon events is greater. For most patients, standard EEG without seizures is sufficient to diagnose epilepsy, but not for the patients included here.

The study has shown that 29% of the referred patients treated for epilepsy did not have epilepsy and these patients may benefit from other treatments. This is of enormous consequences for the patient, his or her social network and society. The current study is retrospective and due to the limitations in the referral material, we do not have a definite referral diagnosis, but we must assume that AED treatment was initiated on suspicion of epilepsy. In the future, referral diagnosis should be a specific requirement to allow for more precise quantification of diagnostic yield. Similar studies have been performed in other centres with similar distribution of epilepsy versus non-epilepsy as indicated in **Table 3** [5-10].

In the study by Shihabuddin and co-workers, the fraction of PNES patients was somewhat larger than in the other studies owing to the fact that they specifically investigated patients with intractable seizures suspected



**TABLE 3**

Results of related studies. The column PNES indicates patients with only PNES while patients with both PNES and epilepsy are included in the epilepsy column.

Reference	Type of patients	Patients, n	Seizures, %	Unresolved, %	Epilepsy, %	PNES, %
Hui <i>et al</i> , 2007 [5]	Diagnostic	100	62	19	63	12
Smolowitz <i>et al</i> , 2007 [6]	All	196	99	5	74	22
Benbadis <i>et al</i> , 2004 [7]	All	251	77	15	52	24
Ghougassian <i>et al</i> , 2004 [8]	All	131	69	21	49	31
Boon <i>et al</i> , 1999 [9]	All	400	65	–	54	8
Shihabuddin <i>et al</i> , 1999 [10]	Diagnostic	125	81	14	18	48
Total		1,203	76	15	52	24

PNES = patient with psychogenic non-epileptic seizures.

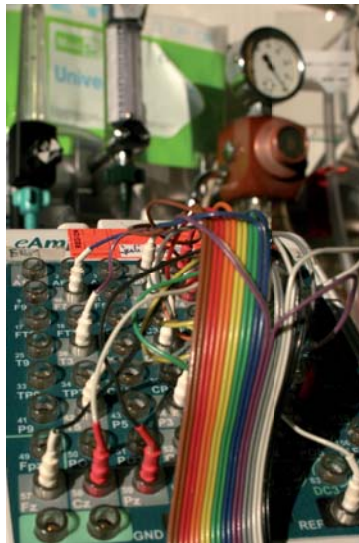
of being non-epileptic [10]. Smolowitz and co-workers did not report the fraction of patients with seizures, but “all registered habitual events”, which seems to be a broader definition including, for instance, medication toxicity. This fact combined with a very long duration of registration (mean 6.6 days) may explain the high fraction of seizures in that study [6].

When we recorded one or more seizures associated with ictal paroxysms, a diagnosis of “epilepsy” or “epilepsy + PNES” was made in all patients. Thus, presence of both seizures and ictal paroxysms allows for an unambiguous clinical diagnosis. Results of similar clarity have been reported by others [7]. On the other hand, when seizures appear without ictal paroxysms or no seizures are recorded, the concluding diagnoses fall in all categories and a substantial fraction remain unresolved both in the present study and in studies by others [5, 7]. Such patients constitute an extraordinary diagnostic problem and often need further diagnostic work-up of for instance the autonomic nervous system.

Video EEG monitoring is an expensive and resource-intensive method of investigation in terms of both equipment and personnel. However, having chronic, uncontrolled epilepsy also has severe economic and sociopsychologic costs for patients, their families and society as a whole. Costs include, among others, repeated requests in emergency wards, admissions for seizures and seizure-related injury. Poorly controlled seizures are associated with reduced cognitive abilities, poor performance in education, increased risk of depression, reduced psychosocial characteristics, early retirement and increased risk of death. Patients with misdiagnosed epilepsy undergoing unnecessary AED treatment are subject to health risks, and psychological and economic costs [11, 12].

PNES is often a difficult diagnosis and many physicians tend to prefer to treat one too many rather than one too little. Our data seem to reflect this phenomenon as 44% of the PNES patients referred were in AED treat-

The patient's outlook during video electroencephalography monitoring.



ment. We find that only 55% of these patients were tapered off medication immediately after the VEM. However, many PNES patients are referred from VEM to psychological intervention and the drug discontinuation is therefore delayed and could not be measured here.

We have investigated the use of VEM in the diagnostic process of patients with repeated seizures. VEM may be used for other purposes such as refining a firm diagnosis of epilepsy, adjustment of medication or as previously mentioned as a part of epilepsy work-up. Over the past ten years, we have seen a steady increase in the non-surgery indication for VEM at Rigshospitalet. We expect to see even more of these patients in the future.

The physicians of the Danish healthcare system seem to make sure that patients suspected of having epilepsy are offered AED treatment. The drawback of this readiness to treat is that a substantial fraction of non-epileptic patients are being treated early in the diagnostic process. If VEM was used more often at early stages of the diagnostic process, fewer patients would undergo unnecessary treatment.

## CONCLUSION

This study indicates that VEM is a very effective investigation in the differentiation between epileptic and non-epileptic seizures.

This is in accordance with studies from other epilepsy centres around the world. VEM is costly, but used in selected patients it substantially reduces the number of patients with non-epileptic seizures stigmatized by a wrong diagnosis and treated unnecessarily with AED. VEM should be considered in patients who continually experience seizures to make a correct diagnosis and optimize treatment.

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**CONFLICTS OF INTEREST:** none

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