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Role of short-term video electroencephalogram in monitoring seizure diagnosis

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Introduction

Epilepsy is known to have a major effect on quality of life of the individuals. More than 50 million people around the world suffer from epilepsy [1].

Given the diverse clinical picture and manifestations of epilepsy, the differential diagnosis is wide, suggesting that a precise diagnosis is often difficult to achieve for physicians creating a practice gap making an accurate and early diagnosis of epilepsy not fulfilled [2].

EEG recordings have been frequently modified for the benefit of proper evaluation of epilepsy. Advances in video EEG monitoring suggested a large spectrum in clinical applications [3].

Determination of the ictal symptomatology differentiates between types of epileptic seizures and also differentiates epileptic from non-epileptic seizures [4].

Inspection of seizure semiology is the first step in evaluation of patients with seizure disorders and is an important tool to predict the symptomatic cause [5].

The most frequently used is outpatient "routine" EEG, lasting 20–30 min, to diagnose individuals with suspected seizure disorders [6].

Long-term video EEG monitoring (LVEM), carried out over days to weeks, is mostly performed for inpatients in the presurgical assessment of epilepsy to characterize complex epileptic syndromes and to record seizure frequency [7].

Short-term video EEG monitoring (STVEEG) is lasting for less than 24 h. It takes advantage over long-term video EEG monitoring that it is less resource- and cost-intensive than long-term video EEG monitoring [8].

The present study aimed to assess the benefit of Short-term video EEG monitoring in the diagnosis of patients with seizure disorders.

Subjects and methods

This is a cohort study carried out on 80 patients complaining from seizure disorders. The study was carried out at Cairo University Hospitals, the period from November 2016 to January 2018.

The experimental method was approved by the ethical committee of the national research center 20 December 2016, under registration number 16465.

The study included 80 patients complaining from seizures, of both sexes. The pseudoepileptic group was further subdivided of numbers of males and females following the new diagnosis after STVEEG. The age of the studied patients ranged from 8 to 59 years, which were subdivided into 3 groups according to the onset into childhood-onset including 60 patients, juvenile-onset (11 patients) and adulthood-onset epilepsy (9 patients). Patients were recruited from epilepsy clinic at Cairo University Hospital with the following inclusion criteria: epileptic patients (regardless of whether symptomatic, idiopathic, focal, or generalized), available routine EEG with previously positive findings. The following were excluded from the study: patients with age less than 8 years or more than 59 years and associated chronic medical condition (heart diseases, metabolic diseases).

All participants were submitted to thorough clinical assessment including careful general medical assessment and detailed medical history of the seizure (including the full description of the seizure), in addition to the results of any previous brain imaging if present (CT or MRI brain).

Neurophysiological tests including digital short-term video EEG examination.

The brand of the used machine was EBNeuro Galileo/EBNeur via P.Fanfani 97/A Firenze, Italy. The high-frequency filter was 70 Hz and the time constant 0.3. The paper speed was 30 mm/sec and the sampling rate

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250. All the records included unipolar, referential montage, and bipolar montages.

EEG recording were done while the patient was lying in a dorsal recumbent position in a semi-illuminated quiet room with his eyes gently closed at the Clinical Neurophysiology Unit, Cairo University Hospitals. In a separate control room, the video EEG was continuously monitored by an EEG technologist utilizing a video-electroencephalograph system. The EEG scalp electrodes were applied according to the International 10-20 electrode placement system. A cap was used for each recording.

Regular antiepileptic drugs were not ceased or tapered for the test nor modified by any means. Hyperventilation (for 3 min) and intermittent photic stimulation (using a photic strobe lamp at 10 different frequencies ranging between 1 and 25 Hz, for 5 s at each frequency followed by 5 s of rest) as provocation techniques. When psychogenic non-epileptic seizures and pseudo non-epileptic seizures were suspected in the referral, verbal suggestion was not used to induce habitual events.

Each video EEG record lasted for not less 30 min as a start, if the video captured any clinically relevant findings which was only applied for patients with previous generalized epileptiform activity on routine recording, whose STVEEG showed a focal onset of those generalized epileptiform activities as mentioned in the inclusion criteria in which the diagnosis changed from generalized to focal-onset of the generalized epilepsy, the record was being terminated. If this was not the case, the record was continued for at least 2 h recording up to 8 h recording according to the referral and/or the tolerability of the test by the patient.

Interpretation of EEG was analyzed by visual inspection of concurrent split-screen video and EEG. The distinction between epileptiform and non-epileptiform sharp transients usually is made intuitively but bearing in mind certain guidelines [9].

In the ictal phase, mental status was examined by checking the response to commands, orientation, and language function. The site of beginning and type of motor semiology, clonic and/or postural and focal or lateralizing motor deficits during spontaneous movement were all registered. In the postictal phase, any spontaneous abnormal behavior was notified as automatisms, combativeness, or unresponsiveness and the time course of resolution was detected.

Statistical analysis

Data were coded and entered using the Statistical Package for the Social Sciences (SPSS), version 25IBM, USA; 2017 [10]. Data was summarized using mean, standard deviation, median, minimum, and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data.

Comparisons between quantitative variables were done using the non-parametric Mann-Whitney test [11]. For comparing categorical data, Chi square ($\chi 2$) test was performed. Exact test was used instead when the expected frequency is less than 5 [12]. P values less than 0.05 were considered as statistically significant.

Results

There were 48 males (60%) and 32 females (40%) included in this study. The current study found an increase in the number of female patients in the pseudo non-epileptic seizures after the STVEEG diagnosis. There was an increase of patients with pseudoseizures from 2 (2.5%) to 7 (8.8%). These increased 5 patients (6.3%) were females (6.3%) in the childhood-onset group, leading to a tremendous change in the diagnostic value of the SVEM by 25%.

Their ages were between 8 and 59 years with a mean age of 17.85 ± 10.58 years subdivided into three groups; childhood-onset including 60 patients (75%), juvenile-onset including 11 patients (13.75%), and adult-onset including 9 patients (11.25%). The three groups were compared to each other as regards the change in the diagnosis before and after STVEEG, which showed a major incline in the number of patients with childhood onset epilepsy who were diagnosed after STVEEM as focal epilepsies as shown in the following Table 1. The duration from the first clinical fit was 9.39 within a mean of 8.24.

Detailed medical history focusing on the history of the previous clinical events (aura, main event, lateralization, eye, mouth, urinary/fecal incontinence, postictal alertness), family history regarding the clinical events and consanguinity is illustrated in Table 2. The three age groups were compared to each other as regards the change in the diagnosis before and after SVEEM, which showed a major incline in the number of patients with childhood onset epilepsy who were diagnosed after STVEEM as focal epilepsies as shown in Table 3.

Indications for short-term video EEG recording were follow-up in 60 patients (75.0%), uncontrolled fits in 13 patients (16.2%), and for diagnosis in 7 patients (8.8%). The provisional diagnosis was altered after short-term video EEG monitoring in 50 patients (62.5%) of the referred patients. The greatest change in the diagnosis was a decline seen in the numbers of patients with the diagnosis of epilepsy and was an increase in the number of the patients with pseudo non-epileptic seizures which increased from 2 (2.5%) to 7 (8.8%). These increased 5 patients (6.3%) in pseudo non-epileptic seizures were females (6.3%) in the childhood-onset group, leading to a tremendous change in the diagnostic value of the STVEEG by 25% and moreover its impact on the management lead to gradual withdrawal to the antiepileptic

Table 1 Comparison between childhood, juvenile, and adulthood onset in the change of diagnosis before and after the SVEM

Diagnosis	Childhood onset	Juvenile onset	Adulthood onset
Generalized epilepsy	− 21	− 3	− 1
Focal epilepsy	+ 16	+ 3	+ 1
PNES	+ 5	0	0

PNES pseudo non-epileptic seizures

Table 2 Clinical history among patients of both eventful and non-eventful groups

			Eventful (n = 21)		Non-eventful (n = 59)	
			Count	Percent	Count	Percent
Aura		Abdominal pain	0	0	1	1.7
		Blurring of vision	1	4.8	0	0
		Dizziness	1	4.8	3	5.1
		Headache	2	9.5	9	15.3
		Tachycardia	0	0	1	1.7
		Vomiting	0	0	1	1.7
		No	17	81.0	44	74.6
Main complaint		Arrest of movement	3	14.3	2	3.4
		Eye squeeze	1	4.8	0	0
		Jerking	5	23.8	6	10.2
		Jerking and stiffness	9	42.9	39	66.1
		Stiffness	3	14.3	12	20.3
Shift of body side		Bilaterally	17	81	49	83.1
		One side	4	19	10	16.9
Eye situation		Cannot tell	2	9.5	6	10.2
		Closed	5	23.8	9	15.3
		Deviated to one side	1	4.8	3	5.1
		Deviated upwards	6	28.6	32	54.2
		Staring	7	33.3	9	15.3
Incontinence during the event		Fecal incontinence	1	4.8	2	3.4
		Urinary incontinence	3	14.3	28	47.5
		None	17	81	29	49.2
Mouth		Deviation to one side	0	0	1	1.7
		Frothy secretion	11	52.4	38	64.4
		Tongue bitten	3	14.3	8	13.6
		None	7	33.3	12	20.3
Postictal alertness		Alert	2	9.5	2	3.4
		Confused	6	28.6	12	20.3
		Drowsy	3	14.3	14	23.7
		Sleepy	10	47.6	31	52.5
Family history	Positive	First degree	3	14.3	7	11.9
		Second degree	5	23.8	11	18.6
	Negative		13	61.9	41	69.5
Consanguinity		Positive	9	42.9	23	39
		Negative	12	57.1	36	61

N number

Table 3 Diagnosis of the patients before and after the short-term video EEG monitoring

Diagnosis	Before SVEM*	After SVEM*	Percent of Change
Generalized onset epilepsy	51 (63.7%)	26 (32.5%)	− 25 (49)
Focal onset epilepsy	27 (33.8%)	47 (58.8%)	+ 20 (74)
Pseudo non-epileptic seizures	2 (2.5%)	7 (8.8%)	+ 5 (250)

*SVEM** short-term video EEG monitoring

medication until final removal of the medication, decline of generalized onset epilepsy from 51 (63.7%) before monitoring to 26 (32.5%) after monitoring, leading to change in the management from medication of generalized epilepsy to those of focal onset generalized epilepsy. However, the control of fits could not be assessed in the current study as it was not included in this research; however, better prognosis is expected after the classification of the studied patients.

For the patients with focal onset epilepsy as a provisional diagnosis before the short-term video EEG monitoring, there was an increase in their number from 27 (33.8%) to 47 (58.8%) after the short-term video EEG monitoring as illustrated in the Table 4.

The current study classified the epileptic patients into subcategories, where the patients having generalized onset seizures were (32.5%) subdivided into 21 (80.8%) with generalized onset motor tonic clonic epilepsy, 2 (7.7%) with generalized onset motor myoclonic epilepsy, and 3 (11.5%) having generalized onset non-motor absence epilepsy. Also, the focal onset seizures were 47 (58.8%) patients subdivided into 22 (46.8%) having frontal lobe epilepsy, 14 (29.8%) having temporal lobe epilepsy, 9 (19.1%) having benign centro-temporal epilepsy, and 2 (4.3%) having benign occipital lobe epilepsy and accordingly the management was redirected for each classified type and shifted or modified to the specific medication regimen for that type, for better prognosis. A significant positive correlation was found between the change in the diagnosis from generalized to focal onset epilepsy and the MRI findings (r = 0.34; P value = 0.002)

As a marker of diagnostic utility of video EEG monitoring, we examined "accuracy" of the short-term video EEG monitoring as a diagnostic tool in seizure disorders to differentiate epileptic from non-epileptic events, classification of seizure type, and localization of epileptogenic zone, so we found that the diagnostic utility of the short-term video EEG monitoring regarding the detection of the habitual event in the epileptic patients was 17.5% (95% CI 9.91 to 27.62%).

Discussion

This study was carried out on 80 patients, they were 48 males (60%) and 32 females (40%). It appears worldwide that females have a marginally smaller annual incidence of epilepsy than males, this gender divergence may be multifactorial but it is usually attributed to the greater exposure of males to risk factors for remote symptomatic epilepsy and acute symptomatic seizures, particularly head injury, stroke, and CNS infection [13].

The current study found an increase in the number of female patients in the pseudo non-epileptic seizures after the STVEEG diagnosis. There was an increase of patients with pseudoseizures from 2 (2.5%) to 7 (8.8%). These increased 5 patients (6.3%) were females (6.3%) in the childhood-onset group, leading to a tremendous change in the diagnostic value of the SVEM by 25%, which matches the previous study by Villanueva et al. [14] who found that the distribution is close to 50% with a slight predominance of females over males.

Table 4 Comparison of short-term video EEG monitoring studies regarding its diagnostic yield

Reference	*N*	Age (mean) in years	Length (mean) in h	ES yield* %
This study (2018)	80	8–57 (18)	0.5–8 (3)	17.5
Desai et al. [19]	155	8–67 (32)	35–75 (47) min	16.6
Seneviratne et al. [21]	175	16–68 (36)	(3.8)	6.9
Tallawy et al. [15]	34	15–73 (22)	(6)	5.9
Kamel et al. [20]	36	(25.2)	(2)	13.9
Modur et al. [16]	179	11–86 (39)	4–4.5	5
Benbadis et al. [8]	74	> 18	1–2	2.7
McGonigal et al. [27]	143	14–75	40–50 min	4.9
Del Giudice et al. [22]	100	< 17 (6)	(2)	25
Srikumar et al. [23]	45	3–11 (7.9)	(4.6)	40

N number, *ES yield** estimated yield

In this study, the patients' age ranged from 8 to 59 years with a mean age of 17.85 ± 10.58 years. They were divided into childhood-onset epilepsy (75%), juvenile-onset (13.75%), and adult-onset (12.25%). After STVEEG, there was major incline in the number of patients with childhood-onset epilepsies who were diagnosed as focal epilepsies. This could be attributed to the fact that focal epilepsies are more common in the childhood-onset epilepsies such as benign childhood epilepsy with centro-temporal spikes, childhood epilepsy with occipital paroxysms, and mesial temporal lobe epilepsies. The duration from the first clinical fit was within 9.39 years with a mean of 8.24 ± SD. Most reports showed a general trend towards an increase in epilepsy prevalence during adolescence or early adulthood. Most studies in developing countries, prevalence of epilepsy remains stable in the third and fourth decades and typically drops after the fifth decade of life [15].

Different indications were requested for this short-term video EEG monitoring, including 60 patients for follow-up (75.0%), 13 patients for being uncontrolled (16.2%), and 7 patients to be diagnosed (8.8%), which agreed with the study carried on 36 patients by Tallawy et al. [16], whose indication of video EEG monitoring aimed from assuring the diagnosis of pseudo non-epileptic seizures, classifying the epileptic event and detecting its active focus, and diagnosing other non-epileptic events. Although it was an indication in the current study, the appearance of interictal discharges during routine EEG record of patients with pseudoseizures to demonstrate that they could have some irrelevant EEG discharges changes, but not as generally known that all pseudoseizures are free on routine EEG. These irrelevant changes could be non-specific, evidenced by a study published in *Epilepsia* (2002) under the name of "Interictal EEG abnormalities with pseudogenic non-epileptic seizures."

According to the presence of habitual event in the video recording, the short-term video EEG monitoring was divided into two groups: 21 eventful video EEG monitoring (26.2%) and 60 non-eventful video EEG monitoring (73.8%), similar to the study which carried on 179 patients by Modur and Rigdon [17] where, during the entire outpatient video EEG monitoring, 39 of their patients (22%) had habitual events. However, the habitual events appeared in greater percent of the recorded short-term video EEG monitoring study carried out by Tallawy et al. [16], where a diagnostic event was recorded in 21 out of 36 patients (58.3%) within the 2 h of monitoring.

The main semiology recorded from the pseudo non-epileptic seizures group was whole body rigidity together with jerky movements, rigor-like movements, teeth clenching, eye fluttering, and pelvic thrusting, the same recording as Magaudda et al. [18] who classified psychogenic non-epileptic seizures by video EEG analysis according to these semiology together with other features such as minor limb tremors, waxing-and-waning patterns, vocalization.

The diagnostic value "accuracy" of short-term video EEG monitoring depends upon the capture of clinical events in question. Accordingly, the diagnostic yield of short-term video EEG monitoring for the detection of epileptic seizures in this study was 17.5% which was compared with the findings of most studies illustrated in Table 3. Similar diagnostic yield percentages16.6% and 13.9% were detected in previous studies by Desai et al. [19] and Kamel et al. [20], respectively [19, 20], while a higher yield of 40% in the study by Srikumar et al. [21], most probably due to overrepresentation of patients with intractable epilepsy with frequent seizures; the diagnostic yield percentage varies widely between studies, reflecting the differences in criteria used among studies to calculate diagnostic yield and discrepancies in patient cohorts.

A change of diagnosis following short-term video EEG monitoring was considered in this study as change in the diagnosis of the disease (the patient was considered to have epilepsy, but proved as pseudo non-epileptic seizure disorders and vice versa) and diagnosis of a form of epilepsy other than the one considered a priori (based on the clinical history and examination previously performed). Accordingly, there was a change in the provisional diagnosis in this study which was 62.5%, by comparing our results with other previous studies as illustrated in Table 4.

In the present study, the outcome was described as successful classification of epilepsy, and demonstration of non-epileptic psychogenic events. This study proved the clinical utility of short-term video EEG monitoring in suspected epileptic patients. So video EEG monitoring can be used as a daytime (2–3 h) procedure with a high yield (62.5%) in differentiating the nature of recurrent, paroxysmal behaviors that occur on a daily, weekly, and monthly basis compared to other studies shown in Table 5. Moreover, short-term video EEG monitoring was found as a very useful procedure in differentiating epileptic seizure versus psychogenic non-epileptic seizure (250% percentage of change). Finally, short-term video EEG monitoring could lead directly to an immediate and beneficial alteration of the classifying epileptic seizure types and clinical management in (49–74%) of patients.

Conclusion

The diagnosis of seizure disorders is a difficult and common clinical problem. The correct and proper timely diagnosis may improve the outcome and saves medical costs. Short-term video EEG monitoring could lead to crucial changes in both the diagnosis and management in a great portion of the monitored patients. The great change in the diagnosis could be

Table 5 Comparison of video EEG monitoring studies regarding the change of diagnosis

Reference	*N*	Age (mean) in years	Length (mean) in h	Type of test	Percentage of change
This study	80	8–57 (18)	0.5–8 (3)	SVEM*	62.5
Foong et al. [24]	108	> 18	1–5 days	LVEM*	58
Bettini et al. [3]	226	(34)	(18.6)	SVEM	57
Seneviratne et al. [21]	175	16–68 (36)	3.8	SVEM	30.9
Villanueva et al. [25]	100	(34.4)	(30)	LVEM	65
Valente et al. [26]	39	(6.9)	(12)	SVEM	71.8
Srikumar et al. [23]	45	3–11 (7.9)	3–6 (4.6)	SVEM	22

N number, *SVEM** short-term video EEG monitoring, *LVEM** long-term video EEG monitoring

easily achieved including an increase in the "non-epileptic" category. The optimal duration for short-term video monitoring recording time is 2–3 h.

Recommendations

Follow-up of patients was not the aim of the current study and not mentioned from the start. Therefore, follow-up researches are recommended to follow-up patients rediagnosed by STVEEG as the current study and monitor the control of seizures in those patients.

Abbreviation

LVEM: Long-term video EEG monitoring; SVEM: Short-term video EEG monitoring; SPSS: Statistical Package for the Social Sciences

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Authors' agreements

All authors have read the manuscript and agreed to the content and submission to this journal with their approval for their ordership and all have the appropriate permission/rights to the reported data.

Authors' contributions

MN and HR contributed to the research idea, data acquisition, data analysis and interpretation, and manuscript writing and reviewing. MA contributed to the manuscript reviewing. MM contributed to the performance of the statistical analysis and revising the results, and data analysis and interpretation. OE contributed to the data acquisition, data analysis, and interpretation. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to current Cairo University regulations and Egyptian legislation but are available from the corresponding author on reasonable request and after institutional approval.

Ethics approval and consent to participate

The aim and procedures of the study were explained to all participants and an informed written consent was obtained, while in cases of patients under 16 years, the written consent was taken from their accompanied parent before being included in the study. The study was approved by the Ethical Committee of the National Research Center on 20 December 2016, under registration no. 16465.

Consent for publication

Not applicable

Competing interests

The authors declare that we have no competing interests (financial and non-financial). We declare that the research was conducted in absence of any commercial relationships that could be of any potential conflict of interest.

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