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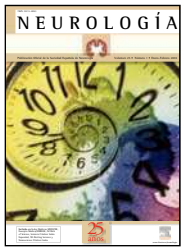

ORIGINAL ARTICLE

Usefulness of Video-EEG monitoring in patients with drug-resistant epilepsy ☆

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Video-EEG;
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Abstract
Objective: To evaluate the characteristics of patients on whom long-term Video-EEG monitoring is performed in a specialist centre and to assess its suitability to study refractory epilepsy patients.
Methods: A prospective analysis and study of Video-EEG monitoring was performed in a series of 100 refractory epilepsy patients from a single centre. The analysis included demographic data, the time until the first seizure, the methods used to provoke seizures, and the outcome (usefulness, change in the management, pharmacological and surgical improvement). A subgroup analysis based on diagnosis was performed.
Results: The study was performed mainly on young people (mean 34.4 years) and the first seizure appeared in a mean of 30 hours, requiring most of the patients to withdraw the medication. Nevertheless, there were no cases of status epilepticus. The usefulness of the test was high in all the groups. The management was changed in 65%of the patients with pharmacological and surgical improvement.
Conclusion: Long-term Video-EEG monitoring is a suitable test to study refractory epilepsy patients. The main problem in our country is accesibility.

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PALABRAS CLAVE
Video-EEG;
Farmacorresistente;
Epilepsia;
Cirugía

Utilidad de la monitorización Video-EEG en los pacientes con epilepsia farmacorresistente

Resumen
Objetivo: Evaluar el patrón de pacientes a los que se realiza monitorización prolongada Video-EEG en un centro especializado en epilepsia y valorar la utilidad de dicha técnica en la epilepsia farmacorresistente.
Métodos: Se realizó el estudio y análisis prospectivo de la monitorización de 100 pacientes consecutivos con epilepsia farmacorresistente correspondientes a un solo centro. Se analizaron los datos demográficos de la serie, el tiempo trascurrido hasta la primera crisis, las maniobras de provocación de crisis y el rendimiento de la prueba (utilidad del test, cambio de actitud, mejoría en el ajuste farmacológico y mejoría quirúrgica). Se realizó un subanálisis en diferentes grupos diagnósticos.
Resultados: El estudio se realizó fundamentalmente en población joven (34,4 años) y la media de horas trascurridas hasta la primera crisis fue de 30, requiriendo en la mayoría de pacientes (90%) retirar la medicación antiepiléptica. Pese a ello, no se produjo ningún caso de status epiléptico. La utilidad del test fue elevada en todos los grupos permitiendo cambiar el manejo de los pacientes en un 65%, lo cual se tradujo en mejorías tanto a nivel farmacológico como quirúrgico.
Conclusión: La monitorización prolongada Video-EEG es una técnica adecuada para el estudio de pacientes con una epilepsia farmacorresistente, siendo el mayor problema en nuestro medio su difícil accesibilidad.

Introduction

Long-term video-EEG monitoring consists of a simultaneous recording of the patient's clinical situation (video) and their electroencephalographic activity (EEG), over a prolonged period of time, generally for several days. The used of prolonged monitoring dates back to the fifties when Gastaut and Bert suggested that it would be useful to record the EEG in conditions that were as close to the patient's ordinary, everyday life.[1] This technique was further developed starting in the seventies and even more markedly so in recent years. The advances in digital technology and costs has brought video-EEG monitoring from a situation of being a technique used exclusively at centres highly specialized in epilepsy to being used in general hospitals. However, this situation is not entirely reproducible in Spain, where accessibility to continuous prolonged monitoring is still complicated.[2] Thus, in some of the existing units, such as our centre, having access to such a test entails a waiting list of approximately one year.

Based on the recommendations of the ILAE, the indications for long-term video-EEG monitoring can be summed up as follows: *1.* Differential diagnosis between epileptic and non-epileptic seizures. *2.* Detection, characterization, and quantification of critical events in order to reach a diagnosis of the type of seizure and the type of epilepsy. *3.* Documentation of the circadian pattern of seizures. *4.* Sleep study in the so-called cognitive epilepsies. *5.* Pre-operative evaluation of candidates for epilepsy surgery. *6.* Monitoring *status epilepticus* in Intensive Care Units.[3]

The present work seeks to establish the pattern of patients in whom long-term video-EEG monitoring is performed at a centre specializing in epilepsy and to assess the usefulness of this technique in our setting in drug-resistant epilepsy.

Material and methods

Patients

The study has been conducted at the Multidisciplinary Epilepsy Unit at the "La Fe" University Hospital, which has a two-bed unit dedicated to long-term video-EEG monitoring. All the patients included in the study presented drug-resistant epilepsy. They were selected at the specialized clinic and video-EEG monitoring was carried out as part of the full work-up for drug-resistant epilepsy.

In this work, a prospective analysis has been made of the first 100 patients (i.e. consecutive patients) on whom video-EEG recording was performed at the unit. With the purpose of homogenizing data, only those patients in whom the video-EEG recording was carried out using surface electrodes were included in this study. Those patients in whom the video-EEG recording was made using semi-invasive electrodes (foramen ovale) or invasive electrodes (subdural) were excluded. In the case of one patient who had undergone monitoring on two different occasions, only the data corresponding to the first monitoring were included in the analysis. In addition to the video-EEG monitoring, all patients also underwent a clinical evaluation and at least one neuroimaging test as part of the study process. Subsequent clinical follow-up has also been conducted either independently of the unit or in coordination with the centres that had referred patients for inclusion in the study.

The recording performed on all patients consisted of wired telemetric video-EEG monitoring with a 128-channel recording unit and another 32-channel unit. Patients are admitted for a maximum of 7 days, a duration deemed optimal for the recording of seizures. In the event that over the course of 7 days no seizure has been recorded, the opinion is that the patient should be re-admitted for study. During the recording, antiepileptic medication is withdrawn either partially or completely until a sufficient number of seizures has been recorded. In the case that the patient presents a seizure that may represent a risk, medication is reintroduced, depending on the unit's protocol. Other manoeuvres are also performed during the recording with the aim of provoking critical events, such as sleep deprivation. Once enough seizures have been recorded, the antiepileptic medication is completely introduced once again and patients remain in the centre for at least 24 hours until they return to their baseline status. Patients are checked at all times by nursing staff trained in the diagnosis and treatment of epileptic seizures.

Data analyzed

Demographic data/Characteristics of the recording performed

Age, gender, stay (in days) in the Video-EEG Unit, time to first seizure (number of hours), classification by groups depending on hours: (<24, 25-48, 49-72, 73-96, 97-120, 121-144, no seizure), withdrawal of antiepileptic drugs, use of sleep deprivation.

Carrying out video-EEG monitoring

Usefulness of the test: 1. Diagnosis of epilepsy versus other paroxysmal disorders. *2.* Typification of the type of epilepsy. *3.* Use for preoperative evaluation.

Change of attitude (diagnosis and/or treatment management) following video-EEG monitoring: a change in attitude shall be defined as: *1.* Change in the diagnosis of the disease (the patient was considered to have epilepsy but he/she does not or *vice versa*). *2.* Diagnosis of a form of epilepsy other than the one considered *a priori* (based on the clinical history and examinations previously performed). 3. Study enabling epilepsy surgery to be performed later.

Improvement in pharmacological adjustment following video-EEG monitoring (this datum has only been assessed in those patients in whom epilepsy surgery has not been performed). An improvement is deemed to have been made when the monitoring has been essential in considering a change in a patient's drug treatment to one appropriate for his/her diagnosis, when the treatment prior to the study is considered inappropriate.

Surgical improvement (this datum has only been assessed in those patients who have undergone epilepsy surgery). A surgical improvement is deemed to have taken place when the frequency of the patient's seizures improves after surgery and the indication was made following the video-EEG monitoring.

Patients were classified into 4 diagnostic groups based on the data obtained from the video-EEG monitoring, on the clinical data collected upon the patient's admission to the study, or on the subsequent clinical evolution if epilepsy surgery is performed. *1. Temporal lobe epilepsy:* these present clinical semiology during seizures and/or EEG recording compatible with this type of epilepsy and/or a lesion on the temporal lobe on a neuroimaging study, or surgery on the temporal lobe has been performed and the patient is seizure-free. *2. Extratemporal lobe epilepsy:* these present clinical semiology and/or EEG recording compatible with this type of epilepsy and/or an extratemporal lesion on a neuroimaging study or extratemporal surgery has been performed and the patient is seizure-free. *3. Generalized epilepsy:* these present clinical semiology and/or EEG recording compatible with this type of epilepsy. *4.* Non-epileptic psychogenic seizures *(NEPS):* analysis of the semiology and of the EEG recording determines the diagnosis of non-epileptic seizures.

Statistical analysis

The statistical tests used depending on the type of data analyzed were as follows: *chi-square test, Z-test*, and *T-test*. The reader will find the specific tests used in each analysis in the results section. Those analyses with a $p<0.05$ were deemed to be statistically significant.

Results

A total of 100 patients were studied; their distribution by groups with respect to diagnosis reveals 52 patients with temporal lobe epilepsy, 24 with extratemporal lobe epilepsy (16 frontal, 5 parietal, and 3 occipital), 11 with generalized epilepsy, and 13 who displayed NEPS. The overall results and the results by groups are shown in table 1 and table 2.

Insofar as gender is concerned, there is a slight predominance of females in the group of patients analyzed. With respect to age, a pattern of young people (34.4 years) is observed. No statistically significant differences are detected between the different groups.

As regards the *stay in the Video-EEG Unit*, the mean duration of stay is 4.99 days, with a minimum of 2 days in order to complete the study. No patient stayed at the Unit for more than one week of study. No significant inter-group differences are seen. When analyzing the *time needed for the first seizure to appear* the mean is just under 30 hours. There is a trend toward presentation of the seizure in the first 24 hours of stay at the Video-EEG Unit (close to 60% of the patients). Only 5% of the patients presented seizure after 5 days. In 3% of the patients, no seizure was recorded, despite reaching the 7-day maximum study time. No significant inter-group differences are seen, although a trend is perceived among the NEPS in comparison to the remaining groups, in that the first seizure does not occur within the first 24 hours.

The analysis of *antiepileptic medication withdrawal* shows that it had to be used in almost all patients (90%), requiring full withdrawal in more than 50% of the patients. Significant inter-group differences are observed; these differences are seen between the group with temporal lobe crises and the group of subjects with generalized seizures, as well as between the group of NEPS versus the group with extratemporal, generalized crises ($p<0.05$) (*Z-test*). In order to be able to record the crisis, drug discontinuation is greater in the patients with temporal lobe epilepsies and in the patients with NEPS than in the subjects with extratemporal, generalized seizures. Other inducing factors, such as sleep deprivation has only been used in just over one quarter of the patients, with no significant differences detected

Table 1 Descriptive analysis of the general characteristics of the Video-EEG study

	General	Temporal	Extra-temporal	Generalized	NEPC
Patients	100	52	24	11	13
Gender (M/F)	44/56	23 (44%)/29 (56%)	9 (37%)/15 (63%)	6 (55%)/5 (45%)	6 (46%)/7 (54%)
Age (years)	34.4±11 (10-69)	37.0±12 (10-69)	31.5±10 (15-53)	27.7±8 (17-38)	35.2±13 (15-66)
Stay in the Video-EEG Unit (days)	4.99±1.29 (2-7)	5.0±1.3 (2-7)	4.7±1.2 (3-7)	4.7±1.5 (2-7)	5.2±0.9 (4-7)
Hours until 1st crisis					
Mean	28.7±28 (1-144)	30.1±31 (1-144)	25.2±23 (2-109)	27.1±33 (1-122)	31.1±21 (4-62)
<24 hours	59 (59%)	32 (61%)	14 (58%)	8 (72%)	5 (38%)
25-48 hours	21 (21%)	9 (17%)	6 (25%)	1 (9%)	3 (38%)
49-72 hours	11 (11%)	5 (9%)	2 (8%)	1 (9%)	3 (23%)
73-96 hours	1 (1%)	1 (2%)	0	0	
97-120 hours	3 (3%)	2 (4%)	1 (4%)	0	
121-144 hours	2 (2%)	1 (2%)	0	1 (9%)	
No crisis	3 (3%)	2 (4%)	1 (4%)	0	
AEDs					
No withdrawal	10 (10%)	1 (2%)	4 (36%)	4 (31%)	1 (7%)
Partial withdrawal	35 (35%)	17 (32%)	6 (54%)	6 (46%)	1 (7%)
Total withdrawal	55 (55%)	34 (65%)	1 (9%)	3 (23%)	11 (84%)
Sleep deprivation					
No	72 (72%)	36 (69%)	18 (75%)	10 (91%)	8 (61%)
Yes	28 (28%)	16 (31%)	6 (25%)	1 (9%)	5 (38%)

NEPC: non-epileptic crises; AEDs: antiepileptic drugs; M: male; F: female.

between the different groups. Despite the manoeuvres used, there was not a single case of *status epilepticus*.

Insofar as the *usefulness of the test* is concerned, the main indication was for pre-operative evaluation (61%) and a diagnosis of epilepsy was the least common indication (16%). The test was seen to be more widely used to evaluate surgical candidates in patients with temporal lobe epilepsy, in comparison with the group of individuals suffering

Table 2 Usefulness of Video-EEG monitoring

	General	Temporal	Extra-temporal	Generalized	NEPC
Usefulness of the test					
Diagnosis of epilepsy	16 (16%)	1 (1.9%)	2 (8.3%)		
Typification	23 (23%)	6 (11.5%)	8 (33.3%)	9 (81.8%)	13 (100%)
Preop evaluation	61 (61%)	45 (86.5%)	14 (58.3%)	2 (18.2%)	
Change following VEEG					
Yes	65 (65%)	31 (59.6%)	14 (58.3%)	7 (63.6%)	13 (100%)
No	35 (35%)	21 (40.4%)	10 (41.7%)	4 (36.4%)	
Drug improvement					
Patients	64 (64%)	23 (44%)	20 (83%)	8 (73%)	13 (100%)
Yes	28 (43%)	4 (18%)	8 (40%)	4 (50%)	12 (92.7%)
No	36 (57%)	19 (82%)	12 (60%)	4 (50%)	1 (7.3%)
Surgical improvement					
Patients	36 (36%)	29 (55,8%)	4 (17%)	3 (27%)	
Yes	35 (97%)	29 (100%)	3 (75%)	3 (100%)	
No	1 (3%)	0 (0%)	1 (25%)	0 (0%)	

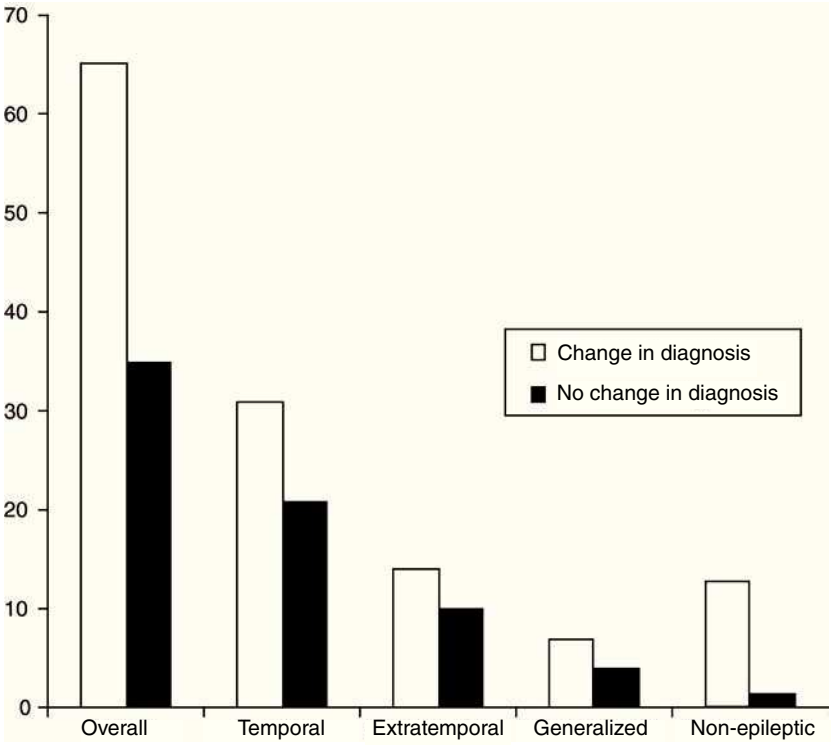

Figure 1 Usefulness of the test in the different groups.

extratemporal, generalized crises ($p<0.05$) (*Z-test*). The test is used more frequently to diagnose the type of epilepsy in the group of patients with generalized seizures versus those with temporal lobe and extratemporal lobe crises ($p<0.05$) (*Z-test*). *Changes in diagnosis or treatment management following video-EEG* were made in 65% of the patients. Upon analysis of the different groups, it is evident, first of all, that changes are made in diagnosis and/or management, without observing any significant differences between the groups; nevertheless, the group in which is it most useful is in the group of patients with NEPS, as the diagnosis of epilepsy that all the patients present until the study is performed can be changed to a diagnosis of NEPS ($p<0.05$) *(Z-test).* The distribution by groups is summarized in figure 1. As regards the *improvement in drug treatment,* treatment was optimized following the video-EEG study in 64% of the patients. An improvement in the patients' clinical status (fewer seizures) was achieved in 43% of the cases. Significant differences are observed between the group of participants with NEPS and that of patients with temporal lobe epilepsies, with the greatest pharmacological improvement seen in the group of NEPS ($p<0.05$) (*Z-test*). The distribution by groups is summarized in figure 2. As regards *surgical improvement,* surgical treatment was performed in 36% of all the patients studied. The group in which surgery is most commonly used is in patients with temporal lobe epilepsy (55.8%). No significant differences are seen between the different groups.

Discussion

First of all, video-EEG monitoring in this study is seen to be carried out principally in the young adult population (34 years) in all the groups studied. One work carried out on 110 patients studied with video-EEG to establish a diagnosis of epilepsy revealed a somewhat higher mean age (39 years).[4] The mean age was also somewhat higher (40.5) in a study that assessed video-EEG monitoring in 131 patients admitted for diagnostic and pre-surgical evaluation.[5] With respect to the breakdown by gender, the distribution is close to 50%, with a slight predominance of females over males (44/56), similar to other studies (62/37)[5] or (57/43).[4] The greater proportion of females studied may be accounted for by the greater presentation of NEPS.

The mean stay in the unit is 5 days; this is similar to that found in other studies in which the mean is reported as being approximately 5.6.[4] In those works in which many children are included, with a greater number of events, the stay decreases and varies between 1.5[6] and 2.8 days.[7] The mean time elapsed until the appearance of the first seizure is 30 hours, with a trend toward presentation within the first 24 hours (60% of the patients); a predisposition to present after this period of time can be observed in NEPS. The results are consistent with another prior study,[8] in which the first event was recorded during the first two days of monitoring. Nevertheless, in this study, no significant differences were found with regard to the early appearance of seizure in patients with epileptic seizures versus those that had NEPS. The possibility of using seizure induction in the case of studies performed for diagnostic purposes may shorten the time to first seizure; thus, at one centre where this method was used, it was possible to record the first seizure in the course of the first 24 hours in 77% of the patients.[9] It cannot be used in cases in which patients are undergoing assessment for pre-surgical evaluation (similar to our centre) in which the mean time to the first seizure goes back up to 25.7 hours.[10]

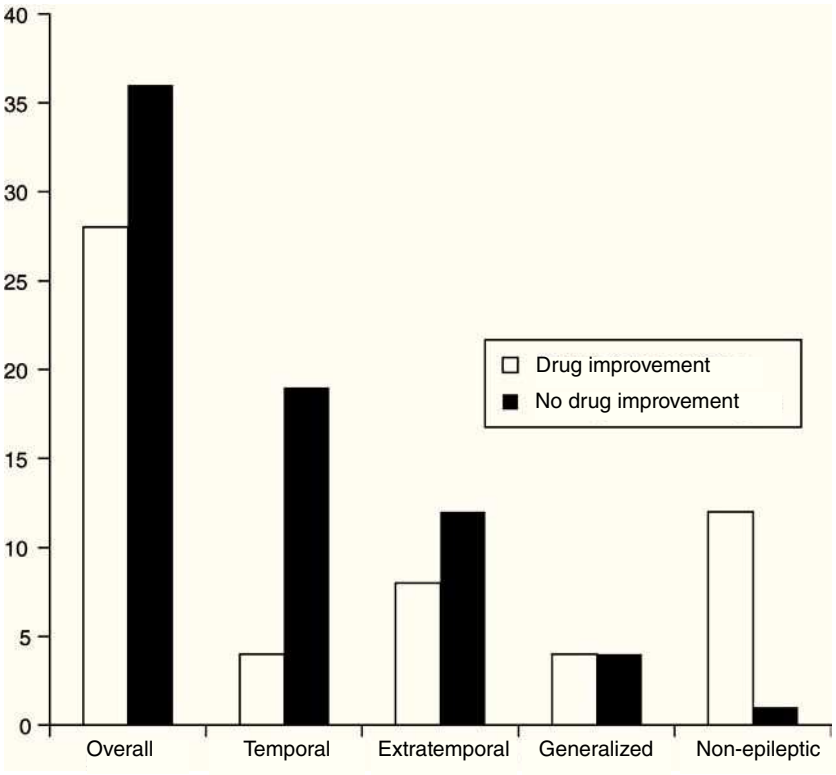

Figure 2 Drug improvement in the different groups.

The analysis of the manoeuvres used to foster the appearance of seizures reveals that medication must be discontinued in 90% of the patients. Comparatively, Lobello et al. in their study, mention that "medication was suddenly reduced in almost all the patients",[8] whereas in another study in which the effectiveness of video-EEG was studied at a tertiary centre in India, the antiepileptic medication was withdrawn in 80.4% of the cases.[11] However, it is more important to assess whether drug withdrawal entails the appearance of complications. At our centre, the discontinuation of antiepileptic drugs did not give rise to a single case of *status epilepticus*. These results are better than those coming out of other studies that, generally speaking, are also acceptable. Thus, in one work performed in 514 patients, epileptic seizures were recorded in 169; the appearance of *status* was reported in 3% when video-EEG was carried out.[12] Nonetheless, in all the series (including ours) an increase in seizure clusters or in the appearance of CSG is observed.[12-14] Sleep deprivation as a manoeuvre to trigger seizures was less widely used in our series (25%). In general, its usefulness in triggering seizures is likewise endorsed by the literature, although its use in video-EEG monitoring is less efficacious than drug withdrawal.[15]

With respect to performance, the test performed well in recording seizures and was capable of recording seizures in 97% of patients. The efficaciousness of video-EEG is corroborated in other studies, although the figures are no higher than those achieved at our centre. Hence, for instance, in one study in which 444 patients were studied to establish a diagnosis of epilepsy or another type of paroxysmal disorder, seizures were recorded in 75% of the cases, although the individuals were monitored only a few hours per day for between 1-5 days,[16] whereas in other studies likewise performed for diagnostic purposes, but in which 24-hour per day monitoring was performed for several days, the percentage of patients in which events were recorded exceeded 80%.[8] Lastly, a final study carried out in 102 patients who were monitored 24 hours a day for 4-6 days and in which patients were included for diagnosis and, in particular, for preoperative evaluation (similar to our study), the test recorded events in just over 90% of the patients.[14]

The analysis of indications in which long-term video-EEG monitoring was used shows that the leading indication in our series is preoperative evaluation (61%), especially in patients with temporal lobe epilepsy. The use of this type of testing to diagnose epilepsy versus other paroxysmal events is the least common indication (16%). The high percentage of patients in whom the study is used for pre-surgical evaluation is based on the difficulty involved in having access to the test in our setting, with the effect that its use in this indication must be maximized in comparison with the diagnosis of epilepsy, in which other alternatives can be sought, such as video-EEG recordings lasting several hours or out-patient recordings. All of this contributes to making it extremely complex to have large series available in our setting in which the monitoring is evaluated as a tool with which to diagnose epilepsy versus other events, as occurs in other countries.[17]

One of the fundamental aspects when analyzing the usefulness of video-EEG is the change in diagnosis/management following such a test in comparison to the patient's prior situation. In our study, a change is made in 65% of the patients, with the NEPS group being the one to benefit the most, given that diagnosis and treatment

strategy is changed in all cases. The usefulness of video-EEG monitoring has been corroborated in any number of studies, some of which were already published at the beginning of the 1980s; thus, Binnie et al. evaluated a total of 181 consecutive video-EEG recordings with largely diagnostic purposes, in which they obtained clinically useful information in 72% of cases.[18] The results of a study conducted on 40 patients are also from the same period; in this case, the diagnostic classification was changed in 19 (47.5%) and seizure frequency was reduced in 24 (60%) following video-EEG.[19] More recent studies, such as the one performed by Ghougassian et al. made it possible to change the diagnosis in 58% of the 131 patients studied.[20] In more specific populations, the results are also informative; for instance, in a study carried out on 283 children, more than 20% of the seizures would not have been correctly diagnosed without a video-EEG recording.[21]

An improvement in pharmacological titration that makes it possible to change the patient's prior treatment and to establish the proper treatment for each diagnosis is seen in 64% of the patients, with improved seizure control in 42% of patients and those who benefit most are those with NEPS. In turn, surgery is performed in 36% of the patients studied. In the temporal lobe group, surgical treatment is used in a larger percentage (55.8%), with improvement being observed in 97% of patients at the time the study was conducted (many patients are pending a longer time course). The high degree of usefulness video-EEG provides for choosing the most appropriate treatment is confirmed in other series; thus, in one study carried out in 100 patients, for preoperative evaluation for the most part, the initial diagnosis was changed in approximately 50% of the patients presenting a crisis, with a change in medical treatment following video-EEG monitoring (given that surgical treatment was out of the question) in 72% of the patients, and observing improvement in 70% of all patients who did not undergo surgery. Surgery was considered in 32% of the patients in whom this treatment had been contemplated.[22] Finally, in another work analyzing the usefulness of video-EEG monitoring to optimize the diagnosis as to the type of seizure and epileptic syndrome, the medication being used was changed once an accurate diagnosis had been reached in 66% of the patients.[20]

Therefore, it can be concluded that the importance of making the correct diagnosis that can be achieved with video-EEG monitoring may represent an improvement in the patient's health status, quality of life and, possibly, social and occupational integration.

Conflict of interest

The authors state that they have no conflict of interest.

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