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Efficacy of Video Electroencephalography in the Classification of Epilepsy

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كفاءة تخطيط الدماغ الفيديوي في تصنيف داء الصرع

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Abstract

Background:

Epilepsy is common neurological disease that affect people of all ages, genders, ethnic backgrounds, and cultures, regardless of their geographical location. It is also considered the second cause of neurological diseases in the world.

This study aims to study the usefulness of video electroencephalography recording in the classification of patients with epilepsy according to ictal and interictal findings supplemented with clinical history and detailed description of the event.

Materials and methods:

The study was a cross sectional study conducted in the period between September 2022 until April 2023 conducted in neurology ward/ video EEG room in Al-Sadeq teaching hospital in Al-Hillah city. It's included 47 patients. Patients are recruited from video electroencephalographic room in neurology ward after being diagnosed to have epilepsy by experienced neurologist. The diagnosis of epilepsy by the neurologist depends on clinical history including detailed history of the ictal event by the patient, his family supported by analysis of video recording of the ictal event, imaging studies if needed and finally by ordinary electroencephalogram examination done at the hospital for 20-30 minutes. The diagnosis and classification were based on the latest reports of international league against epilepsy.

Results:

The study results showed the percent of patients who had interictal discharges through electroencephalography recording 91.48%, and 10.5% of patients had ictal state throughout recording. The classification of seizure subtype according international league against epilepsy-2017 was 11 patient classified as focal onset seizure and 36 of them had generalized onset. Also video electroencephalogram results in altering the initial classification of epilepsy in 57.45% of patients.

Conclusion:

Video electroencephalography is a powerful tool in the classification of epileptic syndromes.

Keywords: Video-EEG, Epilepsy, interictal discharges, ILEA-2017 classification.

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Introduction

Epilepsy is a chronic neurological disorder that affects about 50 million individuals worldwide, or about 0.5% of all diseases that affect humans[1], the "International League Against Epilepsy" (ILAE) in 2017 introduces two Conceptual and Operational definitions of epilepsy, Conceptual definition "epilepsy is a disorder of brain characterized by an enduring Predisposition to generate epileptic seizures, and by the neurobiologic, cognitive, psychological, and social consequences of this condition. The definition of epilepsy requires the occurrence of at least one epileptic seizure[2]." Operational definition of epilepsy, epilepsy is defined when an individual has:

"1. at least two unprovoked or reflex seizures >24 hours apart,

2.one unprovoked or reflex seizure and a probability of having another seizure similar to the general recurrence risk after two unprovoked seizures (≥60%) over the next10 years,

3. an epilepsy syndrome [3]."

While epileptic seizure is defined as "a transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain", this definition implies that seizures are self-limited[4]. The International League Against Epilepsy changed its classification of seizure types and epilepsy types in 2017 as in figure (1)[5]. Classification is an important aspect of epilepsy management, a clear and well-defined classification system can help people with epilepsy, caregivers, healthcare personnel, researchers, policymakers, and insurers to set a better understanding of the condition, communicate effectively, and provide appropriate care and treatments[6].

The ILAE 2017 seizure classification relies heavily on semiological parameters to classify seizures into generalized onset, focal onset or unknown onset seizure[7].

Video electroencephalogram(video EEG) is a diagnostic test that involves the simultaneous recording of EEG and video of patient's clinical behavior over extended periods of time in a specifically equipped room, to evaluate patients with paroxysmal disturbances of cerebral function[8], and video EEG typically involves recording the EEG signal continuously for at least an hour is typically required for a diagnostic video EEG, and recording is usually based on specific needs identified in the physician's EEG request, in addition to the EEG recording, video monitoring is also used to capture any behavioral or clinical events that may occur during the recording, the duration of a video EEG usually range from one hour to 24 hours, and in some cases, it may be necessary to extend it for many days or even weeks in order to make an accurate diagnosis[9].

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Aim

The research aims to Study the usefulness of video electroencephalography recording in the classification of patients with epilepsy according to ictal and interictal findings supplemented with clinical history and full description of the event.

Patients and Methods

The study was a cross sectional study conducted in the period between September 2022 till April 2023. The study's sample size will be Calculated according to the following formula adopted for sample size calculation in cross sectional studies [26].

N=Z2P(1-P)/d2
Where:
N:sample size.
Z: statistic corresponding to level of confidence which equals to 1.96 as the level of confidence is 95%.
P: expected prevalence of epilepsy syndrome.
d: precision which equals to 5% as the prevalence of disease is between 10-90%.
The prevalence of epilepsy in Arabic countries is 6.9 per 1000.

According to formula sample size=11.

In this study takes all patients that attend to neurology ward, it included 47 patients (25 males and 22 females, with ages ranging between 12 and 52 years).

Patients enrolled in study Diagnosed by clinical, EEG and imaging as having epilepsy by an experienced neurologist and referred to perform video EEG recording which was conducted in neurology ward in video EEG room in Al-Sadeq teaching hospital in Al-Hillah city.

Exclusion criteria

1-Patients with diseases known to cause EEG abnormalities like migraine and degenerative disease of the brain.

2-Pateints with brain surgery or head trauma.

All subjects enrolled in the study undergo the following examinations:

1- History and clinical examination.
2- Electroencephalographic recording.

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Electroencephalogram Recording

The EEG recording was submitted 4-6 hours for Video EEG monitoring, eyes opened for 10 min and eyes closed for 10 min, hyperventilation for 5 min, intermittent photic stimulation for 2 minutes and repeated hyperventilation and IPS more than one time, followed by sleep EEG recording.

The video EEG was recorded using a 22-electrode EEG machine Nihon Khoden, with arranging electrodes according to standard 10–20 international system.

Electroencephalographic analysis

The EEG technical details are high cut filter 70 Hz, low cut filter 1 Hz, time constant 0.3, impedance <5000 ohms. The sensitivity of EEG is kept between 7-15 uv/second. The EEG record was displayed as waveforms of varying morphologies and frequencies, and analysis for the presence of interictal discharge, frequency and type of ictal EEG change that observe together with video record. Analysis of EEG records along with video recording is done by an experienced clinical neurophysiologist who was blind to patient's history or initial diagnosis proposed by the neurologist. The data obtained from video EEG are then incorporated along with the patient's history and other clinical and imaging data and discussed with the neurologist to have a final diagnosis and a classification of epilepsy syndrome.

Localizing normal or abnormal brain waves in bipolar montages is usually accomplished by identifying "phase reversal," a deflection of the two channels within a chain pointing in opposite directions.

In the referential montage, generally, the electrode with the largest upward deflection represents the maximum negative activity in a referential montage.

After ensuring that the EEG is free of artifacts, impedance is below 5 Kohms, stable baseline and all electrodes are well conducting, the researchers will start EEG recording. The EEG record consists of different stages or phases as shown below:

1- Recording non-activation stages:

a- Eye closure phase

This is the first part of the EEG record, during which the patient is asked to close eyes voluntarily with minimal contraction of extraocular muscles and without blinking or moving head while he is lying down on the bed, recording continued for 15 minutes.

b- eye open phase:

It represents the second stage of the EEG recording, by asking the patient to open the eye with a fixed gaze, to minimize artifact, also the eye opening recording continues for 15 min. With monitoring video recording for any attack of the ictal state that might occur through recording.

2- Recording activation stages:

a- Hyperventilation stage:

This phase will continue from 3 to 5 minutes and repeated 2-3 times with periods of 2 minutes apart. During hyperventilation, close monitoring of the patient's condition and EEG is needed due to potential development of ictal events.

b- Intermittent photic stimulation (IPS):

Starting this stage with asking the patient to fix his/her gaze on photic source instrument that constantly flashes toward patients face at incremental rate (flashes 1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 30, 33, 50, and recovered), without blinking or moving eye, photic stimulation for 3 min with repeated intermittent photic stimulation 2 or 3 times throughout recording.

Statistical analysis

All statistical analyses were performed using SPSS software (version 23). For continuous data use t-test and represent as mean ±SD, for categorical data use Chi square test and represent the number and the percentage. P value < 0.05 was considered significant [26].

Ethical Approval

This study was approved by the committee on publication ethics at Babylon University/College of Medicine, which certified at 675 on July 21, 2022, and the verbal consent for participation was obtained from patients.

Results

The results of the study showed the percentage of patients had interictal discharges through EEG recording 91.48%, and 10.5% of patients were had ictal state through recording, and the types of IEDs differ according to each type of seizure, and the number of patients were had IEDs, as shown in table (1).

And the types and the frequency of IEDs are shown in figure (1).

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Table (1): Types of IEDs in each seizure type, with the number of the patients had IEDs.

Seizure Type	No. patient	Type of epileptiform discharge	Number and percent of patient in each type IEDs
GTC	21	Spike wave activity	**9 (19.14%)**
		Spike activity	**7(14.89%)**
		Sharp wave activity	**3(6.37%)**
		No IED	**2(4.25%)**
JME	10	Spike wave activity with poly spike	**4(8.5%)**
		4-spike wave activity	**4(8.5%)**
		4-spike wave activity with poly spike	**2(4.25%)**
JAE	3	3-spike wave activity	**3(6.38%)**
Focal to bilateral tonic clonic	4	Right frontal spike with secondary generalization.	**2(4.25%)**
		Left frontal spike with secondary generalization.	**1(2.12%)**
		Left temporal with secondary generalization.	**1(2.12%)**
Temporal lobe epilepsy	3	Temporal spike	**2(4.25%)**
		No IED	**1(2.12%)**
Frontal lobe epilepsy	3	Frontal spike	**3(6.38%)**
CAE	2	3-spike activity	**2(4.25%)**
Focal seizure with impaired awareness	1	No IED	**1(2.12%)**

GTC=generalized tonic clonic; JME= juvenile myoclonic epilepsy; JAE= Childhood absence epilepsy; CAE= Childhood absence epilepsy. Values are expressed as number (percentage).
Results are shown as numbers (percentage).

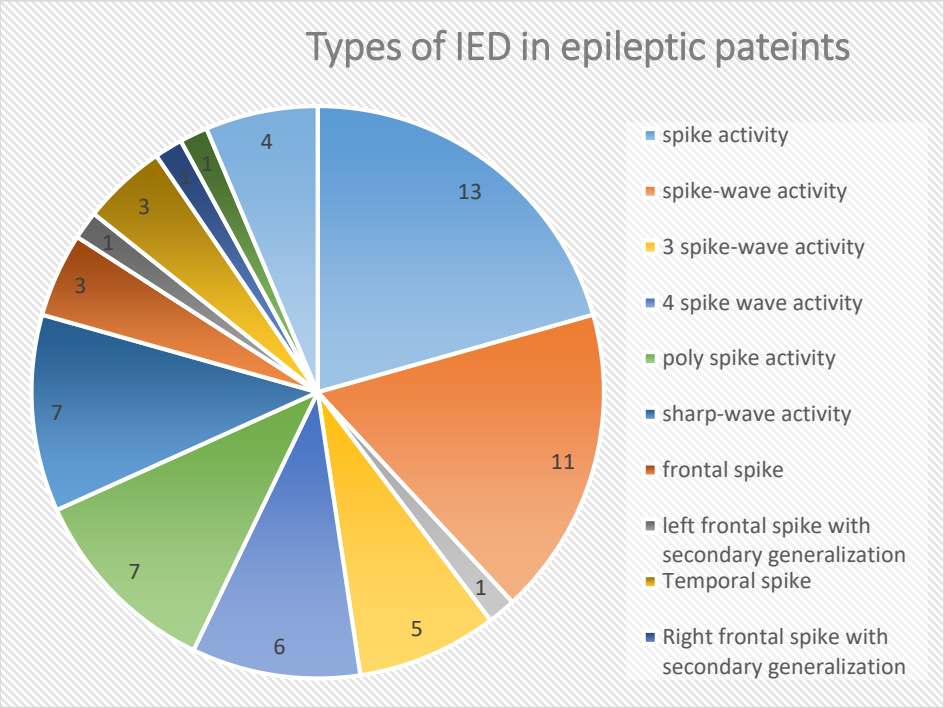

Figure (1): Types and frequency of interictal discharges.

Classification of seizures types

Classification of seizures according to ILAE_2017, and the number of the patients in each type are shown in table (2).

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Table (2): Classification of seizures according to ILAE-2017.

Focal onset				Generalized onset			
Aware		Impaired awareness	Focal to bilateral tonic clonic.	Motor		**Non-motor(absence)**	
		1(2.1)%	4(8.5)%				
Frontal lobe epilepsy	3(6.4)%			Tonic-clonic	21(44.7)%	Childhood absence epilepsy	**2(4.3%)**
Temporal lobe epilepsy	3(6.4)%			juvenile myoclonic epilepsy	10(21.3)%	juvenile absence epilepsy	**3(6.4)%**

Results are shown as numbers (percentage).

Classification of seizures before and after video EEG

After video EEG diagnosis of seizure type change in 27(57.45%) of patients as show in table (3):

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Table (3): Classification of seizure before and after video EEG monitoring.

Diagnosis before	Diagnosis after	Number of patients
Generalized tonic-clonic	Generalized tonic-clonic	**20 (42.55%)**
Generalized tonic-clonic	juvenile myoclonic epilepsy	**9(19.14%)**
Focal seizure	Frontal lobe epilepsy	**3(6.38%)**
Benign rolandic epilepsy	juvenile myoclonic epilepsyk	**1(2.1%)**
Absence seizure	Childhood absence epilepsy	**1(2.1%)**
Generalized tonic-clonic	Focal to bilateral tonic-clonic	**4(8.5%)**
Complex partial seizure	Generalized tonic-clonic	**1(2.1%)**
Generalized tonic-clonic	Childhood absence epilepsy	**1(2.1%)**
Focal seizures	Temporal lobe epilepsy	**2(4.2%)**
Complex partial seizure	Temporal lobe epilepsy	**1(2.1%)**
Absence seizures	juvenile absence epilepsy	**3(6.38%)**
Complex partial seizure	Focal seizure with Impaired awareness	**1(2.1%)**

Results are shown as numbers (percentage).

Ictal attack induced through Video-EEG recording

Through activation and non-activation states of video-EEG monitoring, different ictal states were induced in some patients, 10.5% of patients had an ictal state through the recording as shown in table (4).

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Table (4): Ictal state induced through video EEG recording.

Number of patients with ictal state	Ictal state	Type	Activation state and non-activation state
1(2.1)%	yes	staring	**Eye open**
1(2.1)%	Yes	GTC	**Hyperventilation**
1(2.1)%	Yes	Left leg jerky movement	**Eye open and hyperventilation**
1(2.1%)	Yes	staring	**Hyperventilation**
1(2.1%)	Yes	Staring	**Hyperventilation**

Results are shown as numbers (percentage)

Discussion

Types of epileptiform discharges and frequency during Video encephalographic (EEG) recording in each type of seizures

The percentage of patients who had IEDs during the EEG recording was 91.48%, however, the types and frequency of epileptiform discharges differ according to the type of seizure. The most frequent type of IEDs in this study is spike activity, followed by spike-wave activity, as shown in figure (1).

The results of current research explained in table (1) shows that there were 11 patients had Focal seizure, one of them had a focal seizure with impaired awareness diagnosed by clinical feature and seizure semiology, but his video-EEG was normal.

This finding is seen in many other studies and researches like[10] .[10]who revealed that focal onset epilepsy is more likely to demonstrate normal EEG without any IEDs even with a trial of long-term recording and proper application of activation protocols especially in focal seizure with preserved awareness.

More ever, there are 3 patients with frontal epilepsy and all of them had frontal localized IEDs, whereas[11] expresses the EEG of patients with frontal lobe epilepsy up to 40% does not reveal epileptiform discharges. Furthermore in this study there are 3 patients with temporal lobe epilepsy (TLE) 2 of them had predominant temporal spikes through video-EEG monitoring, this does in the same direction as [12] who showed IEDs located in the antero-temporal over the regional temporal field is the characteristic feature of TLE.

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Moreover a studies conducted by [13] and [14] demonstrated that IEDs are found in 95% and 94.4% respectively of TLE patients. Furthermore, there are 4 patients with focal to bilateral tonic-clonic, 3 of them with frontal spikes with secondary generalization and one had temporal spikes with secondary generalization. [11] expressed that the most common type of focal epilepsy associated with secondary generalization is TLE.

Regarding the generalized onset epilepsy, there were 10 participants had juvenile myoclonic epilepsy (JME), all patients had EEG change, varied in types of epileptiform discharge (4-spike wave activity, spike wave activity and polyspike activity), however [15] showing that EEG is abnormal in 50%–85% of patients with JME. As well, there were 4 patients with childhood absence epilepsy, and all of them had IEDs in the form of 3 Hz spike wave activity, this agrees with [16]who showed similar results and detected IEDs in all cases of childhood absence epilepsy. Also there were 21 patients with generalized onset tonic-clonic seizure, the majority of them had IEDs (spike-wave activity, spike activity, sharp wave activity).

This agrees with the results of [14] who showed similar results about IEDs were present in 92% of patients with generalized epilepsy.

In spite, [17], illustrated IEDs during video EEG in 43% of patients with generalized tonic clonic epilepsy. In the same direction, [18]shows that IEDs in patients with generalized onset epilepsy are symmetrical, synchronous, frontally-predominant, generalized spike-wave or polyspike-and-waves.

In the current study, the IEDs appeared in most cases because that video-EEG monitoring was performed for extended periods that permitted the researchers to record any epileptiform discharge occurring at particular time throughout the recording, with video recording that allows the researchers to capture events and compare it with simultaneous EEG record. Furthersome, the researchers applied multiple properly done provocative measures such as hyperventilation and intermittent photic stimulation (IPS) multiple times throughout the recording with the preparation of patients with sleep deprivation and drug tapering as possible.

Classification of Seizures According to ILAE_2017

ILAE-2017 classification is shown in Table (2).

This study, generalized onset seizure (motor, tonic-clonic) appears to be the most common type of epilepsy. This is in contrast to the study of [19] that illustrated focal onset seizures were the most common type (focal aware, focal impaired awareness, and focal to bilateral tonic-clonic). This may be related to, patients with generalized epilepsy are considered more likely to attend to medical care and seeking management than those with focal onset seizures which is usually illustrated by variety of explanations like a tic, psychological cause… etc.

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Classification of Seizures before and after video EEG

In this study, the performance of video EEG results in the ameliorating the initial diagnosis of seizure type in 27 patients (57.45%), as expressed in table (3). This is agreed with the result of [17],which demonstrated that 58% of the diagnosis of epileptic patients was altered as a result of the video EEG.

This finding is explained by the reality that video EEG is a powerful tool for assessing epileptic patients and is very helpful in the diagnosis and classification because it allows the investigator to properly identify the ictal event (if happened) and compare it with time-locked EEG recording, in addition to that it helps in better characterization and understanding of IEDs than ordinary EEG record[20].

Ictal attack induced through Video-EEG recording

During Video-EEG recording in this study 6 patients only (12.6%), developed an ictal state in different stages of recording, as shown in table (4).

A group of the patients (4) developed staring attack for 8-12 seconds (one during the eye opening, 2 during neuropsychological activation -one during arranging Rubik's cube, one during mathematic calculation and reading- and also during hyperventilation stage). Another patient got a generalized tonic-clonic seizure during the hyperventilation which continued for 1 minute.

These findings contradict the study of [21] in which none of the patients experienced clinical seizures while EEG recording.

While other study [22] which showed particular seizure types mainly drop attacks (atonic and tonic seizures) seen in 2.3% of Video EEG monitoring.

Whereas [23] showed epileptic seizures were precipitated by hyperventilation in 2.2% of patients.

As well the study of [24]showed that hyperventilation and intermittent photic stimulation increases the risk of provoking seizures, including GTC seizures.

The explanation of the low rate of capturing ictal events during video EEG recording may be related to the fact that some patients were on regular treatment with reasonable control of seizure or due to the termination of video EEG recording prematurely in many cases based on patient's wish resulting which reduces the chance of catching ictal manifestation[25].

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Conclusions

1.Video-EEG can be an essential tool in establishing a diagnosis of seizure disorder and an essential aspect in the seizure work up, because video monitoring contributes to capturing an event that may occur through recording, with EEG record that helps in the diagnosis of seizure.

2.Video EEG represent a cornerstone in the classification of epilepsy syndromes, that help in choosing appropriate treatment and improving the prognosis of seizure, and help in the change in diagnosis of epilepsy type and reach to definitive diagnosis by video recording to seizure semiology and EEG change that occur associated with it.

Conflict of interests.

There are non-conflicts of interest.

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الخلاصة

المقدمة:

الصرع مرض عصبي يمكن أن يصيب الأشخاص من جميع الأعمار والأجناس والخلفيات العرقية والثقافات، كما أنه يعد السبب الثاني للأمراض العصبية في العالم.

يهدف البحث إلى معرفة كفاءة تخطيط كهربائية الدماغ الفيديوي في تصنيف المرضى المصابين بالصرع وفقًا لشكل النوبه والتغيرات في كهربائية الدماغ اثناء التخطيط معززة بالتاريخ السريري والوصف التفصيلي للنوبه.

طرق العمل:

دراسة عشوائية أجريت في المدة ما بين سبتمبر 2022 حتى أبريل 2023. وشملت الدراسة 47 مريضا مع توزيع عمري بين 12 إلى 52 سنة وفيما كان توزيع الجنس(25 ذكر و 22 أنثى) , كما جمعت عينات المرضى في غرفة التخطيط للدماغ الفيديوي في ردهة الأمراض العصبية في مستشفى الامام الصادق في مدينة الحلة بعد تشخيص إصابتهم بالصرع من قبل طبيب اختصاص جمله عصبيه.

يعتمد تشخيص الصرع على التاريخ السريري بما في ذلك التاريخ التفصيلي للنوبة مدعومًا بتخطيط الدماغ الكهربائي الفيديوي، والدراسات التصويريه إذا تطلب الأمر، وعن طريق فحص تخطط كهربائية الدماغ العادي الذي يتم إجراؤه في المستشفى لمدة 20–30 دقيقة. واستند تشخيص وتصنيف داء الصرع إلى تقرير الرابطة الدولية لمكافحة الصرع – 2017.

النتائج:

أظهرت نتائج البحث أن النسبة المئوية للمرضى الذين أصيبوا بتغيرات في كهربائية الدماغ بين نوبات الصرع من خلال تخطيط كهربائية الدماغ 91.48% ، و 10.5% من المرضى حدثت لهم نوبة صرع اثناء فترة تخطيط كهربائية الدماغ الفيدوي. وكان التصنيف النوعي للنوبات وفقًا لتقسيم الرابطة الدولية لمكافحة الصرع –2017 هو 11 مريضًا تم تصنيفهم على أنهم من نوع متلازمة صرع بؤري مع نوبة بؤرية، وكان 36 منهم من نوع متلازمة صرع معمم مع نوبة الصرع المعمم. كما نتج عن تخطيط كهربائية الدماغ الفيدوي تغيير التصنيف الأولي للصرع في 57.45٪ من المرضى.

الاستنتاج

يعد تخطيط كهربائية الدماغ الفيديوي أداة قوية في تصنيف متلازمات الصرع وتحديد نوعها.

الكلمات المفتاحية: فيديو–EEG الصرع, تغيرات كهربائية الدماغ بين النوبات,ILEA–2017 تصنيف.