Long-term Video-EEG Monitoring Findings in Children and Adolescents with Intractable Epilepsy

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Abstract

Objective

Long Term Video-EEG Monitoring (LTM) may give us important information in the preoperative assessment of these patients. We performed this study for the first time in pediatric age group in Iran.

Materials and Methods

In this cross-sectional study, 43 children between 4 to 18 yr, with intractable epilepsy referred to Shefa Neuroscience Research Center, Tehran, Iran from 2007-2012, were enrolled to study in order to evaluate their long-term video EEG findings.

Results

The patients mean age was 10.07 yr, from which 24 (65.9%) were boys. Seven patients with definite epileptogenic zone were advised to perform lesionectomy surgery. In two patients, there was not any seizure onset focus but corpus callosotomy was advised to control their frequent falling. Eight cases were recommended to perform electrocorticography or invasive EEG monitoring and 26 cases to adjust medical treatment. In three cases, there was not any electrical seizure activity during clinical attacks, so discontinuing anti-epileptic drugs were recommended for diagnosis of conditions that mimic epilepsy.

Conclusion

It is necessary to perform LTM in patients with refractory epilepsy in order to determine their treatment strategy. If there is any doubt about pseudoseizure LTM can help to differentiate epilepsy from conditions that mimic epilepsy.

Keywords: Long term video-EEG monitoring (LTM); intractable epilepsy; Epilepsy surgery

Introduction

A seizure is a paroxysmal involuntary, time-limited change in brain function, resulting from abnormal discharges from cerebral neurons. It is called epilepsy if it occurs two times or more without any provocation (1-3). Intractable epilepsy, if untreated, can lead to cognitive decline, impaired mental and social status, lifestyle disruption and patient dependency (4). The biologic basis of seizure recurrence lies in conditions such as severe epileptic syndromes, underlying neuropathological diseases, abnormal reorganization of neurons, replacement of receptors and...
Clinical images will be recorded for 12 h to a few days. Hence, clinical symptoms and brain waves can be studied simultaneously (12). The test is noninvasive and patient feels no pain or discomfort during hospitalization. The test allows the physician to review the patient’s brain electrical activity when he/she has abnormal behaviors or seizure attacks; to determine the focus of seizure in the brain, diagnose the nature of invasive abnormalities, and select the best and most effective method of treatment (medical or surgical) (8). LTM has been very effective in patients with frequent attacks whose definite diagnosis could not be reached by conventional methods. Using LTM in patients with epilepsy, physician can monitor patient’s 24 h activities, both during sleep and waking hours; to determine the type and frequency of seizures (8). Furthermore, this test helps physician to determine the focus of seizure, differentiate between nonepileptic and epileptic seizures, classify attacks, detect epileptic syndromes, determine the number of seizures and epilepsy mimicking disorders (i.e. tic disorders, sleepwalking disorders, night terrors and cataplexy) (8, 9). Analyzing the results of LTM during and between attacks provides precise knowledge of brain points’ function (10, 11).

As LTM is a new method and due to the lack of studies in this field in Iran, for the first time in Iran, this study aimed to evaluate the long-term video-EEG findings in pediatric and young patients of 4 to 18 yr with refractory epilepsy.

Materials and Methods
This cross-sectional study was conducted from 2007 to 2012, on all pediatric and young patients of 4 to 18 yr referred to Shefa Neuroscience Research Center, Tehran, Iran. They were diagnosed with refractory epilepsy. Inclusion criteria included having a medical diagnosis of refractory epilepsy made by a specialist in Pediatric Neurology and not having a history of surgery for epilepsy. Using a consecutive sampling method, all the 43 patients with refractory epilepsy were recruited in the study.

Ethics permissions for the study were obtained from the hospital authorities and an informed consent was signed by parents of patients.

Data collection instrument consisted of two parts. The
first part included questions on the patient’s age, sex, date of the first seizure, the number of seizures in 2 yr, drugs used so far (three drugs or less) and type of seizure (generalized, partial, mixed). The second part of the data collection instrument included items on EEG findings during the attack (ictal EEG), EEG findings between attacks (interictal EEG), location of the seizure focus, brain MRI information, and the LTM data. The needed data were gathered from the patients’ hospital flies or through clinical observations and interviews with parents.

LTM and behavioral observations were performed on all patients for several hours to several days. In each case, the LTM was stopped and the results were recorded after two or more clinical seizures.

Statistical analysis was carried out using SPSS software version 17 (Chicago, IL, USA). Kolmogorov-Smirnov test was performed to examine the normality of the data. Then, Mann-Whitney U, analysis of variance (ANOVA) and Fisher’s exact tests were used to investigate the relationship between variables. Statistical significance was considered at P-value <0.05.

Results

Totally, 43 patients including 24 boys (55.82%) and 19 girls (44.18%) were enrolled in this study. The mean age of boys and girls was 8.7 ± 12 and 11.13 ± 8 yr, respectively. Twenty-four people (55.82%) had partial seizures, while 11 (25.58%) and eight cases (18.6%) had generalized or mixed type seizures, respectively. No significant relationship was found between patients’ age and type of seizure (P=0.790) (Table 1).

Regarding the clinical semiology of seizure attacks, 53.4% (n= 23) of attacks were focal motor, followed by generalized motor (n= 12, 27.9%), myoclonic (n= 10, 23.2%), dialectric (n= 9, 20.9%), visual aura (n=3, 6.9%), auto motor (n= 2, 4.6%), oral motor (n= 2, 4.6%), atonic (n= 2, 4.6%), hyper motor (n= 2, 4.6%), jelastic (n= 1, 2.3%), epigastric pain aura (n=1, 2.3%), and non-epileptic attacks (n= 1, 2.3%) (Figure 1).

Findings of electroencephalography and Brain MRI were as follows:

Five patients (11.63%) had normal Ictal EEG while 38 cases (88.37%) had abnormal Ictal EEG. Table 2 shows the relationship between Ictal EEG and seizure type and epileptogenic zone.

Moreover, four patients (9.30%) had normal Interictal EEG and 39 patients (90.69%) had abnormal interictal EEG. Table 3 shows the relationship between interictal EEG and seizure type and epileptogenic zone.

There was no significant relationship between seizure type and focus and EEG findings (Table 2 and 3).

There was significant relationship between type and number of attacks (P=0.047) (Table 4). Moreover, no significant relationship was found between ictal and interictal EEG findings and brain MRI findings (P=0.579 and P=0.436) (Table 5). However, a significant relationship was found between results of brain MRI and the type of treatment (P=0.005). Nonetheless, no significant relationship was found between ictal and interictal EEG findings and the type of treatment (Table 6).

Table 7 shows the final medical recommendations prescribed after reviewing the results of LTM and the dedicated brain MRI in 43 patients. First group: Nine patients were recommended having surgery; seven patients (77.7%) with a localized seizure focus were recommended to have lesionectomy surgery. Two patients (22.3%) had no seizure focus but they were recommended to have Corpus callosotomy surgery to prevent frequent falling due to frequent seizures.

Second group: Eight patients were recommended electrocorticography or invasive EEG monitoring to determine the seizure focus precisely.

Third group: 26 patients were recommended to continue but reform medical treatments. Seizure focuses of two patients (8%) were well defined but they were recommended to continue pharmacological treatment because it was at frontotemporal area and there were high risks for motor cortical damaged during surgery. Attacks of three patients were seizure imitators (11.5%), therefore they were recommended to discontinue treatment. One of these patients had hemifacial spasms, one had autism spectrum disorder and one had a non-epileptic attack recommended seeking psychiatric consultation (Table 8).

Discussion

LTM is a specialized form of brain EEG done as continuous and long-term monitoring of brain activity and video recording of clinical behavior. It leads
physicians to select the best and most effective way of treatment for patients with refractory epilepsy (8). Using LTM and Brain MRI we could correctly diagnose the focus of epilepsy in 20 (46.51%) of 43 pediatric patients with refractory epilepsy.

Using LTM, 60 patients were studied with 10 yr of epilepsy. Then, 40% of patients were diagnosed as having pseudoseizures. Therefore, they strongly recommended that LTM is used in diagnosis of symptomatic seizures (13). The effect of LTM was examined before surgery in 56 patients with refractory epilepsy. LTM can detect about 90% of seizure types (9). In this study, the power of LTM in diagnosing the type of seizure was confirmed and 55.8% of seizures were partial and 25.5% were generalized while 6.9% of patients had pseudoseizures. The low incidence of pseudoseizures in pediatric group seems reasonable.

In this study, 6.9% of patients were diagnosed as pseudoseizures and were referred to discontinue drugs. Moreover, eight patients (19.7%) were referred for invasive monitoring. In a study, 454 patients in age range of 11 d to 20 yr were studied using LTM. Totally, 23.6% and 24.9% of patients were diagnosed as generalized or partial seizures respectively; while 35% had pseudoseizures that were recommended to discontinue antiepileptic drugs and nine cases (2%) were referred for invasive monitoring (14).

In the current study, among three patients (6.9%) with pseudo seizures, one patient consumed more than three antiepileptic drugs and two cases consumed three antiepileptic drugs. In a study, 33 (18%) out of 182 patients with refractory epilepsy had pseudo seizures and consumed more than 1.5 antiepileptic and 1.5 psychiatric medications (15).

**In Conclusion,** as a non-invasive diagnostic method, LTM is very useful not only in diagnosing and differentiating the type of seizures (false or true); however, in localizing the seizure focus in children with refractory epilepsy. Therefore, facilities for LTM are created at all specialized centers of epilepsy. Then, the quality of diagnosis and treatment of refractory epilepsy and consequently the quality of life of patients would be improved.

**Acknowledgment**

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**Author’s Contribution**

Y. Ghazavi: substantial contributions to the conception and drafting the work
E.Aayesh Zarchi: Acquisition, analysis
T.Taheri: neurosurgery consultation
M.Safiabadi: Acquisition and analysis of data and interpretation of data for the work
E.Rahimian: MRI interpretation and neuroradiologic consultation
S.Amirsalari: Clinical diagnosis, patient selection for LTM, EEG interpretation and final decisions

All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

**Conflict of Interest**

The authors declare that there is no conflict of interest.
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**Table 1.** Relationship between age and the type of seizure

| Type of seizure | Patients | Age Average | Std. Deviation |
|-----------------|----------|-------------|----------------|
| Partial         | 24       | 9.75        | 4.54           |
| Generalized     | 11       | 10.73       | 3.77           |
| Mixed           | 8        | 10.13       | 3.27           |
| Total           | 43       | 10.07       | 3.83           |
| P               | 0.790    |             |                |

**Table 2.** Relationship between Ictal EEG and type of seizure and epileptogenic zone

|                       | Normal Ictal EEG N(%) | Abnormal Ictal EEG N(%) | Total N(%) | P    |
|-----------------------|-----------------------|-------------------------|-------------|------|
| Generalized seizures  | (0) 0                 | (9.28) 11               | (6.25) 11   | 359.0|
| Partial seizures      | (80) 4                | (6.52) 20               | (4.55) 24   |      |
| Mixed type seizures   | (20) 1                | (5.18) 7                | (6.18) 8    |      |
| Detected epileptogenic zone | (20) 1          | (50) 19               | (5.46) 20   | 210.0|
| Undetected epileptogenic zone | (80) 4         | (50) 19               | (5.53) 23   |      |

**Fig 1.** Semiology of the clinical attacks in patients
### Table 3. Relationship between Interictal EEG and type of seizure and epileptogenic zone

|                          | Normal Interictal EEG/ N (%) | Abnormal Interictal EEG/ N (%) | Total N (%) | P   |
|--------------------------|-----------------------------|--------------------------------|-------------|-----|
| Generalized seizures     | (0) 0                       | (2.28) 11                      | (6.25) 11   | 083.0 |
| Partial seizures         | (100) 4                     | (3.51) 20                      | (4.55) 24   |     |
| Mixed type seizures      | (0) 0                       | (5.20) 8                       | (6.18) 8    |     |
| Detected Epileptogenic zone | (25) 1                   | (7.48) 19                      | (5.46) 20   | 350.0 |
| Undetected Epileptogenic zone | (75) 3                | (3.51) 20                      | (5.53) 23   |     |

### Table 4. Relationship between EEG findings and the number of seizure attacks

| EEG findings | Patients | Number of attacks (mean ±SD) | P   |
|--------------|----------|-----------------------------|-----|
| Ictal EEG    | Normal   | 5                           | (19.47±)39 | 610.0 |
|              | Abnormal | 38                          | (37.37±)74.29 |     |
| Interictal EEG | Normal | 4                           | (03.74±)25.65 | 047.0 |
|              | Abnormal | 39                          | (16.32±)28.27 |     |

### Table 5. Relationship between the EEG findings and Brain MRI

|                  | Normal Brain MRI | Abnormal Brain MRI | Total | P   |
|------------------|------------------|--------------------|-------|-----|
| Ictal EEG        | Normal           | 2                  | 3     | 5   | 0.579 |
|                  | Abnormal         | 13                 | 25    | 38  |     |
| Interictal EEG   | Normal           | 2                  | 2     | 4   | 0.436 |
|                  | Abnormal         | 13                 | 26    | 39  |     |

### Table 6. Relationship between the EEG findings, Brain MRI findings and the type of recommended treatment

|                  | Surgical treatment | Medical treatment | Electrocorticography or Invasive EEG Monitoring | P   |
|------------------|--------------------|-------------------|-----------------------------------------------|-----|
| Brain MRI        | Normal             | 0 (0)             | 14 (93.3)                                   | 1 (6.7) | 0.005 |
|                  | Abnormal           | 9 (32.1)          | 12 (42.9)                                   | 7 (25)  |     |
| Ictal EEG        | Normal             | 0 (0)             | 5 (100)                                     | 0 (0)  | 0.065 |
|                  | Abnormal           | 9 (23.6)          | 21 (55.4)                                   | 8 (21)  |     |
| Interictal EEG   | Normal             | 0 (0)             | 3 (75)                                      | 1 (25)  | 0.550 |
|                  | Abnormal           | 9 (23.1)          | 21 (53.9)                                   | 8 (23)  |     |
### Table 7. Relationship between recommended treatment and results of LTM

| Types of treatment | Patients N (%) | Epileptogenic zone N (%) |
|--------------------|----------------|--------------------------|
| Surgical treatment | (9.20) 9       | Detected (7.77) 7        |
| Invasive EEG Monitoring or Electrocorticography | (7.19) 8 | Detected (25) 2)         |
| Medical treatment  | (4.60) 26      | Detected (3.42) 11       |

### Table 8. Summary of Demographic, Electroencephalographic, Neuroimaging findings and final recommendations in 43 cases undergone LTM

|   | Sex | Age | MRI Finding                              | Inter Ictal EEG | Ictal EEG | Recommendation   |
|---|-----|-----|------------------------------------------|-----------------|-----------|------------------|
| 1 | Female | 12  | Bilateral polymicrogyria and periventricular heterotopia | Nonepileptiform: generalized epileptiform: anterior region of head | Generalized | Surgical          |
| 2 | Male   | 16  | Old hydrocephaly                          | Bilateral       | Nonepileptiform: bilateral epileptiform: left posterior | Continue AEDs |
| 3 | Male   | 9   | Global atrophy of the right hemisphere, Gliosis of right occipital | Left hemisphere | Epileptiform: bilateral | Continue AEDs |
| 4 | Female | 12  | Left partial focal dysplasia              | Left hemisphere | Epileptiform: Left side | Surgical         |
| 5 | Male   | 17  | Signal abnormality in right frontotemporal (growing glioma) | Right fronto temporal | Nonepileptiform: right Frontotemporal Epileptiform: right frontotemporal | Surgical          |
| 6 | Female | 6   | Global atrophy- left hippocampal atrophy | Bilateral       | Epileptiform: right hemisphere | Continue AEDs |
| 7 | Female | 6   | Abnormal right hippocampal atrophy        | NORMAL          | NORMAL     | Continue AEDs      |
| 8 | Male   | 9   | NORMAL                                   | Bifrontal       | Non epileptiform: bilateral, Epileptiform: bilateral | Continue AEDs |
| 9 | Male   | 8   | NORMAL                                   | NORMAL          | NORMAL     | Discontinue AEDs  |
| 10| Male   | 8   | Pachygyria lesion over the right frontal  | Bilateral       | Right anterior temporal | Invasive monitoring |
| 11| Female | 8   | Lesion on left posterior frontal          | Left side       | Left central area | Continue AEDs     |
| 12| Male   | 9   | NORMAL                                   | Right hemisphere | Right temporal | Continue AEDs     |
| 13| Male   | 4   | Widening in frontotemporal (porencephalic cyst) | Bilateral       | Bilateral     | Surgical          |
| 14| Male   | 4   | NORMAL                                   | Frontocentral area | Left posterior head | Continue AEDs     |
| No. | Sex | Age | Diagnosis 1                      | Diagnosis 2          | Diagnosis 3 | Investigation 4 | Treatment 5 |
|-----|-----|-----|---------------------------------|----------------------|-------------|-----------------|-------------|
| 15  | Female | 5   | Abnormal gyration in both frontal | Multi focal          | Bifrontal   | Continue AEDs   |
| 16  | Female | 13  | Hypogenesis of corpus callosum   | Right Frontocentral  | NORMAL      | Invasive monitor |
| 17  | Male   | 9   | Cerebellar atrophy              | Generalized          | Multi focal | Continue AEDs   |
| 18  | Male   | 8   | Left sided hippocampal atrophy  | Left hemisphere      | Left hemisphere | Continue AEDs |
| 19  | Female | 7   | Left hippocampal atrophy        | Left posterior temporal & Right anterior temporal | Both hemisphere | Invasive monitor |
| 20  | Male   | 8   | Increasing signal in hippocampuses (hipocampal sclerosis) volume loss in both hemisphere (atrophy) | NORMAL | Bilateral parieto central | Continue AEDs |
| 21  | Female | 4   | NORMAL                          | Bilateral            | Generalized | Continue AEDs   |
| 22  | Male   | 15  | Abnormal signal in left parietal lobe cortex | Left temporal | Left temporal | Surgical |
| 23  | Female | 5   | Mass lesion in inferior thalamus | Left hemisphere      | Non epileptiform on left hemisphere | Invasive monitor |
| 24  | Female | 10  | NORMAL                          | NORMAL               | NORMAL      | Continue AEDs   |
| 25  | Male   | 10  | NORMAL                          | Generalized          | Generalized | Continue AEDs   |
| 26  | Female | 7   | Atrophy and porencephalic cyst on left hemisphere | Left hemisphere | Left hemisphere | Invasive monitor Discontinue AEDs |
| 27  | Female | 8   | Bilateral hippocampal atrophy   | NORMAL               | Bilateral posterior temporal | Continue AEDs |
| 28  | Female | 6   | Bilateral cortical malformation | Left posterior head  | Left posterior head | Surgical |
| 29  | Female | 13  | NORMAL                          | Bilateral            | Epileptiform: generalized | Continue AEDs |
| 30  | Female | 10  | Mild bilateral hippocampal roundening and medial displacement | Generalized | Epileptiform: bilateral | Continue AEDs |
| 31  | Male   | 9   | NORMAL                          | Left frontal         | Bifrontal, maximum left frontal | Continue AEDs |
| 32  | Female | 8   | NORMAL                          | Frontal              | Multi focal maximum frontocentral | Continue AEDs |
| 33  | Male   | 17  | NORMAL                          | Generalized          | Multi focal | Continue AEDs   |
| 34  | Male   | 8   | Volume loss in right lobe and dilatation on temporal horn of right lateral ventricle | Right temporal | Bifrontotemporal, maximum right temporal | Surgical |
| 35  | Male   | 11  | Volume loss in right hippocampal and right sided hippocampal sclerosis | Right temporal | Non epileptiform, bilateral | Surgical |
| 36  | Female | 13  | NORMAL                          | Right frontal & left hemisphere | Bilateral frontotemporal | Continue AEDs |
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|   |   |   |   |   |
|---|---|---|---|---|
| 37 | Male | 17 | Signal change in right occipital | Right posterior head | Posterior head | Continue AEDs |
| 38 | Male | 14 | Global atrophy | Right temporal | Right hemisphere | Surgical |
| 39 | Male | 12 | Parietocentral lesion | Left central and right hemisphere | Multifocus | Invasive monitoring |
| 40 | Female | 12 | NORMAL | Bilateral | Right centroparietal | Invasive monitoring |
| 41 | Male | 16 | Brain malacia with gliosis and atrophy in left fronto tempo-parietal, mild patchy gliosis in right parieto-occipital | Started bilateral evolution right frontal | Right frontal | Invasive monitoring |
| 42 | Male | 16 | NORMAL | Generalized | Multifocal | Continue AEDs |
| 43 | Female | 14 | NORMAL | Bilateral | Bilateral | Continue AEDs |

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