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Semiological Seizure Classification: Before and After Video-EEG Monitoring of Seizures

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The study objective was to assess the applicability and reliability of the semiological seizure classification in children with epilepsy in outpatient clinics. Ninety patients (age range, 2-16 years) who experienced clinical seizures during prolonged video-electroencephalogram (EEG) monitoring were evaluated. Semiological seizure classification was performed, first based on history obtained from parents of the patient during outpatient follow-up visits and then based on video EEG-monitoring. Kappa statistics (κ) were used to evaluate the consistency of the two rounds of semiological seizure classification. Classification based on history yielded the following distribution: simple motor seizures (66.3%), aura (28%), complex motor seizures (15.8%), special seizures (15.8%), dialeptic seizures (9.3%), and autonomic seizures (3.7%). Classification based on video EEG-monitoring yielded a different distribution: simple motor seizures (55.7%), complex motor seizures (26.9%), automotor seizures (26.9%), aura (23%), dialeptic seizures (22.1%), special seizures (9.6%), and autonomic seizures (1.9%). Negative myoclonic seizures ($\kappa = 1$, $P = 0.000$) and hypermotor seizures ($\kappa = 0.85$, $P = 0.000$) had excellent consistency; somatosensory aura ($\kappa = 0.26$, $P = 0.012$) and automotor seizures ($\kappa = 0.28$, $P = 0.004$) had the lowest consistency. The families or doctors often defined simple motor seizures (decrease of 10.6% from before to after monitoring, $\kappa = 0.44$); the proportion of complex motor seizures changed rather from before to after monitoring (11.1%, $\kappa = 0.33$). Generally, parents can describe seizures quite well. We suggest that semiological seizure classification is a reliable method applicable for everyday use during outpatient visits, especially if seizure semiology is evaluated individually for each component or if the semiological seizure classification is modified or refined for some seizure components (tonic, clonic, versive, conscious, automotor seizures). **© 2007 by Elsevier Inc. All rights reserved.**

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Introduction

The International League Against Epilepsy (ILAE) 1981 seizure classification is based on the semiology of clinical seizures in terms of ictal and interictal electroencephalogram (EEG) findings [1]. ILAE 1989 seizure classification is made by taking into consideration the etiology, starting age, and the brain pathology that served as a cause, except for the epilepsy classification. This classification is complex, and many syndromes are not adequately defined. Although these two classifications have proven to be of considerable clinical value, they could be insufficient to assess clinical pharmacology researches, epidemiologic studies and any anatomic subdivision for epilepsy surgery evaluation. Furthermore, they are not as practical as semiological seizure classification in terms of speed of use and applicability under polyclinic conditions [2-4].

Lüders et al. [5] proposed a new epileptic seizure classification based on ictal semiology. These researchers believe that all clinical information, neurological examination, anatomic and functional neuroimaging, and seizure evolution should be evaluated comprehensively and then should be correlated, to define the epileptic syndrome precisely. Semiological seizure classification emphasizes the differentiation between epileptic seizures and epileptic syndromes. This classification scheme provides common

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terms for ictal symptoms and types, independent of the EEG patterns and of other laboratory findings [5].

In practice, it is difficult to determine the epilepsy pattern reliably in pediatric groups. Classifications using the video-EEG monitoring are the most reliable methods for seizure classification. Because of the requirements of time and expense, however, monitoring is usually applied in seizure classification only in intractable seizures and in presurgical evaluation, for precise localization [2]. There are no comprehensive studies evaluating whether semiological seizure classification is sufficient in children on an outpatient clinic basis [6-10].

The objective of the present study was to assess the applicability and reliability of the semiological seizure classification at outpatient clinics in children with epilepsy.

Patients and Methods

Patients

The study population comprised 90 patients who experienced clinical seizures during prolonged video-EEG monitoring (5 days) at Gazi University Faculty of Medicine, Department of Pediatric Neurology, from January 1998 to January 2004. The patients ranged between 2 to 16 years (mean: 10.6 ± 3.87) in age, 47 female (52.2%) and 43 male (47.8%).

Video-EEG Evaluation

Ictal video-EEG monitoring was performed using the Telefactor Beehive system (Telefactor, Philadelphia, PA). Scalp electrodes were placed according to the international 10-20 system. Trained EEG technicians, pediatricians, and nurses examined the patients during seizures to determine their level of consciousness or responsiveness to external stimuli.

Videotape Review

All the histories and videotapes were reviewed by two pediatricians together: a pediatric neurologist (A.S.) who has been working in the epilepsy center for 15 years and a pediatrician (T.H.) who has been working in the center for 1.5 years.

Seizure Classification

Seizure semiology and classification was described on the basis of semiological seizure classification system by Lüders et al. [5] (Table 1). Seizure characterization based on history obtained from the parents of the patients as a new interview was termed "pre-EEG monitoring classification" and a second characterization, based on video EEG-monitoring, was termed "post-EEG monitoring classification." Thus, all the seizures were classified twice—before and after EEG monitoring—by the same two pediatricians. One pediatrician (T.H.) was blinded to the original clinical and EEG data, neuroimaging findings, and eventual clinical diagnosis; the other pediatrician (A.S) was partially unblinded because of clinical involvement with some patients. Each seizure of these patients was extensively discussed by these two pediatricians. After finalizing the classification system, the seizures of all patients were reviewed in random order. Each of these pediatricians made a written independent assessment and classification of each seizure's symptomatology. In most cases, there was spontaneous agreement on the seizure classification. In the infrequent cases when the two pediatricians disagreed, the videotapes were reviewed again and classified after discussion and final consensus among the investigators. Evolution of seizure symptomatology was expressed as progression from one seizure type to another (e.g., aura, dialeptic seizure, versive seizure, automotor seizure). Poor-quality seizures with deficient sound or image and patients with pseudoseizures were excluded.

Informed consent was obtained from the patients' families. Approval for this study was granted by Gazi University Faculty of Medicine Ethical Committee.

Table 1. Semiological seizure classification (Reprinted with permission from Lüders H, Acharya J, Baumgartner C, et al. Semiological seizure classification. Epilepsia 1998;39:1006-13, by Blackwell Publishing [5])

I. Epileptic seizure
  1. Aura
     - Somatosensory aura*
     - Auditory aura*
     - Olfactory aura
     - Abdominal aura
     - Visual aura*
     - Gustatory aura
     - Autonomic aura*
     - Psychic aura
  2. Autonomic seizure*
  3. Dialeptic seizure†
     - Typical dialeptic seizure*
  4. Motor seizure*
     - Simple motor seizure*
       - Myoclonic seizure*
       - Epileptic spasm*
       - Tonic-clonic seizure
       - Tonic seizure*
       - Clonic seizure*
       - Versive seizure*
     - Complex motor seizure†
       - Hypermotor seizure†
       - Automotor seizure†
       - Gelastic seizure
  5. Special seizure
     - Atonic seizure*
     - Hypomotor seizure†
     - Negative myoclonic seizures*
     - Astatic seizure
     - Akinetic seizure*
     - Aphasic seizure†

II. Paroxysmal event

* Left/right/axial/generalized/bilateral asymmetric.
† Left hemisphere/right hemisphere.

Statistical Analysis

Kappa (κ) statistics and McNemar tests were conducted to evaluate the consistency of the semiological seizure classification between the two occasions, before and after EEG monitoring. The consistency is mild if $\kappa < 0.2$, fair if $\kappa = 0.21$-0.40, moderate if $\kappa = 0.41$-0.60, good if $\kappa = 0.61$-0.80, and excellent if $\kappa \geq 0.81$. A P-value of < 0.05 was considered statistically significant. All the statistical analyses were performed with the software (version 10.0 for Windows; SPSS, Chicago, IL).

Results

At the pre-EEG monitoring classification, 74 of the 90 patients had only one type of seizure, 15 had two different

Table 2. Semiology of epilepsy applied before and after monitoring

Semiology	Before Monitoring, No. (%)	After Monitoring, No. (%)	Change, Percentage Points	κ Value*	*P* Value†
Sample size	n = 107	n = 104			
Aura	30 (28)	24 (23)	5	0.632	0.000
Somatosensory	8 (7.4)	5 (4.8)	2.6	0.257	0.012
Autonomic	2 (1.8)	1 (0.09)	1.71	−0.015	0.880
Abdominal	5 (4.6)	—	—	—	—
Gustatory	2 (1.8)	1 (0.9)	0.9	0.662	0.000
Psychic	13 (12.1)	19 (18.2)	6.1	0.623	0.000
Autonomic	4 (3.7)	2 (1.9)	1.8	−0.031	0.758
Dialeptic	10 (9.3)	22 (21.1)	11.6	0.410	0.000
Simple motor	71 (66.3)	58 (55.7)	10.6	0.440	0.000
Myoclonic	11 (10.2)	12 (11.5)	1.3	0.452	0.000
Epileptic spasm	1 (0.9)	—	—	—	—
Tonic	19 (17.7)	18 (17.3)	0.4	0.354	0.001
Clonic	8 (7.4)	17 (16.3)	8.9	0.044	0.644
Tonic-clonic	47 (43.9)	30 (28.8)	15.1	0.365	0.000
Versive	14 (13)	34 (32.4)	19.4	0.375	0.000
Complex motor	17 (15.8)	28 (26.9)	11.1	0.332	0.001
Hypermotor	3 (2.8)	4 (3.8)	1.0	0.851	0.000
Automotor	14 (13)	28 (26.9)	13.9	0.279	0.004
Gelastic	2 (1.8)	2 (1.9)	0.1	0.489	0.000
Special	17 (15.8)	10 (9.6)	6.2	0.286	0.008
Atonic	9 (8.4)	4 (3.8)	4.6	0.426	0.000
Negative myoclonic	1 (0.9)	1 (0.9)	0	1.000	0.000
Akinetic	—	3 (2.8)	—	—	—
Hypomotor	3 (2.8)	2 (1.9)	0.9	−0.027	0.791
Astatic	7 (6.5)	—	—	—	—
Aphasic	2 (1.8)	1 (0.9)	0.9	−0.015	0.880

* A negative κ value is interpreted as a small number of seizures.
† $P < 0.05$ was considered significant.

seizure types, and 1 had three different seizure types. Of the 107 different types of seizure, 50 seizures consisted of only one semiology, 42 seizures displayed two semiologies, 13 seizures displayed three semiologies, and 2 seizures displayed four semiologies.

At the post-EEG monitoring classification, 80 of the 90 patients had only one type of seizure, 7 had two different seizure types, 2 had three different seizure types, and 1 had four different seizure types. Of the 104 different types of seizure, 45 seizures consisted of only one semiology, 35 seizures displayed two semiologies, 20 seizures displayed three semiologies, and 4 seizures displayed four semiologies.

A summary of the distribution of the seizures, with κ- and *P*-values, is given in Table 2. When the seizure semiology was evaluated according to the history obtained from the patients' parents, the distribution of the seizures was as follows, in descending frequency: simple motor seizures (66.3%), aura (28%), complex motor seizures (15.8%), special seizures (15.8%), dialeptic seizures (9.3%), and autonomic seizures (3.7%). These seizures were evaluated again after prolonged EEG-monitoring. The distribution then was as follows: simple motor seizures (55.7%), complex motor seizures (26.9%) and automotor (26.9%), aura (23%), dialeptic seizures (22.1%), special seizures (9.6%), and autonomic seizures (1.9%).

Although the number of seizure semiologies was small when the degree of consistency for before and after monitoring was compared in the same patient, the negative myoclonic ($\kappa = 1$, $P = 0.000$) and hypermotor seizures ($\kappa = 0.85$, $P = 0.000$) had excellent consistency; gustatory ($\kappa = 0.66$, $P = 0.000$) and psychic aura ($\kappa = 0.62$, $P = 0.000$) had high consistency; and gelastic ($\kappa = 0.49$, $P = 0.000$) and myoclonic seizures (45.2%, $P = 0.000$) had moderate degree of consistency. The somatosensory aura ($\kappa = 0.26$, $P = 0.012$) and automotor seizures ($\kappa = 0.28$, $P = 0.004$) had the lowest consistency.

Simple motor seizures, which were frequently defined both before and after monitoring, and the tonic-clonic seizures (pre: 43.9%, post: 28.8%; $\kappa = 0.36$) had mild consistency between the two occasions using semiological seizure classification.

A negative value of κ in some seizures is interpreted as a small number of seizures.

Discussion

In practice, it is difficult to determine the epilepsy pattern reliably when the classification scheme is applied in pediatric groups during outpatient clinic visits. In daily practice, however, pediatric neurologists and neurologists are frequently confronted with the need to classify based

on seizure observation or description only. Furthermore, there are limited data on this condition [7,8,11-14]. Although in some studies epilepsy classification is performed by using EEG, neuroimaging studies, and clinical history together [7], in others [6-8] a modified epilepsy classification has been proposed for children.

Hamer et al. [7] evaluated 296 video-monitored seizures and correlated the findings with the ictal EEG and neuroimaging studies in 76 consecutive patients (age range, 1-35 months). They defined four types of semiology consisting of epileptic spasm, clonic seizures, tonic seizures, and hypomotor seizures. In the study of Hamer et al. [7], focal motor seizures were reliably associated with focal EEG seizures in the contralateral hemisphere of the infants, whereas generalized motor and hypomotor clinical seizures were either focal or generalized on EEG. Hence, they emphasized that video-EEG monitoring and neuroimaging may be critical for clarifying the focal and generalized nature of the epilepsy in infants [7].

Lüders et al. [5] proposed a new classification based on ictal seizure semiology, as reported by the patient or observers, or as documented during video-EEG monitoring. Any EEG patterns do not affect the semiological classification. According to this classification, the ictal symptoms can be caused by epileptic interference of one of the following four spheres: sensorial, consciousness, autonomic, and motor (Table 1). Therefore, *auras* are ictal manifestations having sensory, psychosensory, and experiential symptoms. *Autonomic seizures* are seizures in which the main ictal manifestations are objectively documented autonomic alterations. *Dialeptic seizures* have as their main ictal manifestations an alteration of consciousness independent of ictal EEG manifestations, so it is confined to both absence and complex partial seizures. *Motor seizures* are characterized mainly by motor symptoms and are subclassified as simple or complex. *Special seizures* include seizures characterized by negative features: atonic, astatic, hypomotor, akinetic, and aphasic seizures [5].

Limited information is available on outpatient application of the semiological seizure classification systems for children [5]. Kim et al. [6] compared the semiological seizure classification and ILAE 1981 seizure classifications for children. They concluded that seizures with multiple concurrent or sequential semiologies can be described well with semiological seizure classification, but cannot be easily classified into a single seizure type [6]. Benbadis et al. [9] studied 78 patients, comparing both semiological seizure classification and ILAE 1981 classifications in reliability and applicability for everyday clinic use. Seizure classification changed significantly between clinically based data and the monitoring based classification data in ILAE 1981 classification. They suggested that semiological seizure classification might be better suited for everyday use, because it is based solely on clinical characteristics [9].

In the present study, the sequence of ictal semiology were diverse, and 55 of 107 seizures (51%) before monitoring and 59 of 104 seizures (56%) after monitoring showed two or more semiologies in a single seizure. That is, more than half of the seizures exhibited seizure evolution, or involved different systems, as Lüders et al. [5] have remarked. The classification of epileptic seizures proposed by ILAE in 1981 is insufficiently phenomenological, so seizure progression is inadequately specified. In contrast, because semiological seizure classification is based entirely on what is observed during the ictal event, it can describe concurrent or sequential ictal phenomena very efficiently. Hamer et al. [7] reported that 53% of children in the first 3 years of life had only a single semiology, and 42% of children had two or more different seizure types. Thus, these authors stressed that using modified semiology is important for exact definition of the seizures and localization in infants [7]. Nordli et al. [8] classified seizures according to both the ILAE and a modified semiological seizure classification (astatic, behavioral, clonic, epileptic spasm, tonic, and versive) in infants (1-26 months); they found that the ILAE classification was not suitable if the classification had to be performed by only clinical history. They further claimed that semiological seizure classification was the suitable method to make seizure classification in outpatient clinics.

Aura is a seizure that affects the sensorial sphere and produces no objective signs other than, occasionally, altered behavior [5]. In fact, physicians can distinguish this condition only if the patient talks about the sensorial experience. Kim et al. [6] concluded that although older children felt and could express auras, 25% of them could not specify their auras. In the present study, the aura had the third best consistency ($\kappa = 0.63$). Aura was determined as 28% from seizure history of the patients and 23% from the video-EEG monitoring findings. Within this semiological category, gustatory aura ($\kappa = 0.66$) and psychic aura ($\kappa = 0.62$) as the most consistent.

In the present study, simple motor seizures were more frequent (66.3%) according to patient history, but the complex partial seizures were identified as more prevalent (26.9%) according to prolonged video-EEG monitoring findings; the counterpart classification frequency from patient history was 15.8%. Although simple motor seizures were frequently described by the parents, this fell in the moderate group for consistency ($\kappa = 0.44$, $P = 0.000$). We therefore that motor seizures should be comprehensively evaluated by the physician during outpatient-clinic visits.

Hypermotor seizures were the second most consistent group ($\kappa = 0.85$, $P = 0.000$), a finding in accord with those of Para et al. [2], in which some semiological seizure classification categories, such as hypermotor and automotor, had a good topographic correlation. Accordingly, they suggested that semiological seizure classification yielded more frequent descriptive information and better characterization of epileptic seizures. Other useful categories in

semiological seizure classification, such as gelastic seizures, were noted only occasionally, precluding full statistical analysis [2]. In the present study, gelastic seizures were low in number, but consistency was ($\kappa = 0.49$) moderate, supportive of the views of Parra et al. [2].

When myoclonic seizures were compared for the before and after monitoring classification, the consistency was moderate ($\kappa = 0.46$). The proportion of these seizures was low (pre-monitoring 10.2%, post-monitoring 11.5%), but nonetheless well described by the patients' parents. The frequency of myoclonic seizures was higher than in other studies [2,6].

After video-EEG monitoring, tonic seizures (17.3%) and clonic seizures (16.3%) were classified at a frequency similar to that of Kim et al. (tonic 20%, clonic 17%) [6]. The consistency between classification before and after monitoring for these two semiologies was mild. We therefore suggest that there may be insufficiency in the definition and realization of tonic and clonic seizures, and that parents should be trained about the descriptions of these seizures.

Because detection of versive seizures was three times greater after monitoring, the families might not have been able to define or realize versive seizures as a seizure component similar to tonic-clonic seizures. Thus, they may need training on this issue as well. Some studies have found that versive seizures may not be identified clearly by the doctors if the eye or head deviation does not promptly occur, and so versive seizures may be underrecognized [6,7].

Dialeptic seizures are unique in the semiological seizure classification system, characterized by an alteration in consciousness as the main ictal manifestation [5]. From the present study, it appears that twice as many dialeptic seizures are diagnosed with video-monitoring than with patient history alone; consistency was moderate ($\kappa = 0.41$). We therefore suggest that parents may not define or realize alteration of the consciousness. Although Kim et al. [6] detected a greater proportion of dialeptic seizures (35%) with video monitoring than in the present study (21.1%), the difference was attributed to our evaluation of seizures with consciousness change as hypomotor seizures.

Alteration of consciousness is difficult to document in infants and young children, and is usually defined as unresponsiveness or decreased responsiveness unrelated to motor alteration [5,6,8,12]. Thus, hypomotor seizure definition is used exclusively in infants and young children, for whom it is not possible to test consciousness during or after the seizures. This semiology is characterized by decrease or absence of motor activity [5,6,8,12]. The number of the children having hypomotor seizures was only 3 (2.8%) before monitoring and 2 (1.9%) after monitoring, numbers too small to allow statistical evaluation. In contrast, Hamer et al. [7] reported 20% hypomotor seizures. The wide age range in the present study (2-16 years) may have contributed to the low values.

In conclusion, we observed that complex motor seizures changed (11.1%, $\kappa = 0.33$) rather from before to after monitoring and special seizures types are described with a rather high consistency (atonic seizures, $\kappa = 0.43$; negative myoclonic seizures, $\kappa = 1$), although the families or the doctors often define simple motor seizures instead (changed 10.6% from before to after monitoring), especially tonic, clonic, versive, and conscious condition.

The moderate or mild degree in the last-mentioned seizures suggests that the semiology should be evaluated individually for each component, or that a modified or new version of the semiological seizure classification be developed for some individual seizure components during outpatient follow-up. Furthermore, patients and their parents should be trained about seizure descriptions, and the history from the parents and the patient should then be evaluated again to confirm the efficacy of the teaching. Nonetheless, the overall findings suggest that semiological seizure classification is the applicable and reliable method for everyday use during outpatient follow-up.

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