Semiological seizure classification of epileptic seizures in children admitted to video-EEG monitoring unit

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We aimed to determine seizure characteristics of pediatric patients with epilepsy, and evaluate if Semiological Seizure Classification (SSC) system is applicable in this cohort.

We retrospectively studied 183 patients, aged between 3 months-18 years, admitted to the video-EEG monitoring unit (VEMU). Most patients suffered from intractable epilepsy with comorbidities, and had structural lesions. Seizures were classified based on ictal video-EEG recordings by using SSC system; 157 patients had only one seizure type, 26 had more than one seizure types. Overall 211 seizures and 373 semiologies were analyzed; 114 seizures (54%) had more than one semiological subtype. The most frequent semiology was motor seizures (78%), followed by dialeptic seizures (12%). The most common subtypes were simple motor seizures (49%); tonic seizures constituted (28.4%) of all semiologies.

We conclude that SSC system is applicable for children with epilepsy admitted to VEMU; complementary EEG and imaging data are required for evaluation of patients with epilepsy.

Key words: semiologic seizure classification, epilepsy, children, video-EEG monitoring.

The etiology and clinical course of epilepsies are heterogeneous; this has led to attempts for classification of epilepsies in order to achieve accurate diagnosis and treatment approaches and determine prognosis. The international classification of epileptic seizures published in 1981 by the International League Against Epilepsy (ILAE)[1], was based on interictal and ictal electroencephalogram (EEG) findings, as well as on the semiology of clinical seizures, which had been almost universally used and become a common language for epileptic seizures among clinicians, along with the classification of epilepsies published in 1989[2]. However, in recent decades, accumulating scientific knowledge related to molecular genetics, neuroimaging techniques, and, in particular, use of video-EEG monitoring for epilepsy surgery, have increased the need for revision of the classifications for seizures and epilepsies, hence an updated classification of seizures and epilepsies was published by the ILAE in 2010[3].

In addition to classifications revised by the ILAE, the semiological seizure classification (SSC) system, based purely on ictal symptoms and signs, was proposed by Lüders et al.[4] in

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1998 as a seizure classification. The usefulness of available classifications including SSC have been previously studied, particularly in adults with epilepsy[5,6]. However, a relatively small number of researchers have used the SSC in childhood[7-9]. We aimed to evaluate the applicability of SSC in infants and children with epilepsy.

Material and Methods

Study design and subjects

This retrospective study was conducted in the video-EEG monitoring unit (VEMU) at Hacettepe University Children's Hospital between August 2005 and December 2007. The study was approved by the Human Research Ethics Committee of Hacettepe University Faculty of Medicine. The video-EEG recordings of 320 children were evaluated, and 183 patients with ictal video-EEG recordings were included. Children who had no ictal recordings and patients with nonepileptiform paroxysmal events were excluded. The clinical data was collected by reviewing medical charts and patient files at the VEMU.

Long term video-EEG monitoring was performed with scalp electrodes placed according to the international 10-20 system. Pediatric residents and nurses examined the patients during seizures to determine their level of consciousness, responsiveness and presence of neurological deficits. Video-EEG recordings were reviewed by two investigators. One investigator (SA) was blinded to patients' clinical and EEG data, the other investigator (DY) was partially blinded because of clinical involvement with the patients. Investigators were not blinded to each other. Seizures were classified based on ictal video-EEG recordings by using the SSC system proposed by Lüders et al.[4].

Statistics

A comparison between the groups was performed using the t-test and/or Mann–Whitney U-test for non-parametric continuous variables in independent samples and chi-square or Fisher's exact tests as appropriate for categorical variables. General descriptive statistics were summarized as counts and percentages for categorical variables; median (minimum–maximum) and also mean ± standard deviation for continuous variables.

Table I. Demographic and Clinical Features of Pediatric Patients with Ictal Video-EEG Recordings.

Characteristics	n	%
Age groups		
0-2 y	14	7.7
3-11 y	105	57.4
12-18 y	64	34.9
Sex		
Male	122	66.7
Female	61	33.3
Age of seizure onset		
< 1 month old	69	37.7
1-12 months old	22	12
1-12 years old	88	48.1
13-15 years old	4	2.1
History of febrile seizures	43	23
Family history of febrile/afebrile seizures	45	24.5
Developmental delay/intellectual disability	101	55.2
Antiepileptic drugs		
1 drug	24	13.1
≥2 drugs	159	86.9
Epilepsy surgery	63	34.4
Brain surgery other than epilepsy surgery	15	8.2

Statistical analyses were performed using SPSS 15.0 and a "p" value of less than 0.05 was considered statistically significant.

Results

The video-EEG recordings of 320 patients were evaluated and 183 patients were included in the study. Ninety-nine patients who had no ictal recordings and 38 patients who had merely nonepileptiform paroxysmal events during their admission to VEMU, were excluded.

The demographics and clinical characteristics of patients with ictal recordings are shown in Table I. The mean age of the patients was 9.5 ± 4.7 years (3 months-18 years). Overall 143 patients were older than 5 years (78%), and 40 patients were 5 years and younger. Almost half of the patients had their initial seizure within the first year of life. The mean age at the time of first seizure, and the beginning of recurrent seizures were 3.2 ± 3.5 years and 3.6 ± 3.6 years, respectively. All patients were on antiepileptic drugs (AED). All, but three patients, had brain magnetic resonance imaging (MRI). Selected patients had single photon emission computed tomography (SPECT), positron emission tomography (PET) and functional MRI studies. About one third of the patients underwent epilepsy surgery. The most common etiological causes were developmental abnormalities of the central nervous system (CNS) (29.5%), perinatal insults (15.3%), and primary tumors of the CNS (8.1%). The underlying etiologies for 35 patients (19.2%) remained unknown (Table II).

According to SSC, 157 of the 183 patients (86%) had only one seizure type, 26 patients had more than one seizure type (24 had two different seizure types (13%) and 2 (1%) had three seizure types). Overall 211 seizures were analyzed in 183 patients; 97 seizures (46%) consisted of a single semiological subtype. The remaining 114 seizures (54%) consisted of more than one semiological subtype, and showed evolution of the clinical behavior of the seizure. Of the 114 seizures, 66 had two semiological subtypes (58%), and 48 seizures had three semiological subtypes (42%). Among 40 patients who were 5 years and younger,

Table II. Underlying Etiologies and Risk Factors for Epilepsy in Pediatric Patients with Ictal Video-EEG Recordings.

Underlying etiologies/Risk factors	N	%
Developmental abnormalities of the central nervous system*	54	29.5
Perinatal insults**	28	15.3
Primary brain tumors	15	8.2
Neurocutaneous syndromes (Tuberous sclerosis, Sturge-Weber syndrome)	11	6.0
Head trauma	9	4.9
Cerebrovascular events	7	3.8
Encephalopathy/encephalitis/meningitis	7	3.8
Mesial temporal sclerosis	7	3.8
Neurometabolic diseases	6	3.4
Hematologic disorders	2	1.1
Genetic syndrome (Rett Syndrome)	1	0.5
Secondary to cardiovascular diseases	1	0.5
Unknown	35	19.2
Total	183	100

*30 patients with cortical dysplasia, **Brain injury due to perinatal asphyxia or prematurity.

19 patients (47.5%) did not show evolution of seizures; in 143 patients who were older than 5 years, 83 did not display evolution of seizures (57%) (p=0.281).

In total, 373 semiological subtypes were analyzed, and summarized in Table III. The majority of the semiologies were motor seizures (291/373 semiological subtypes, 78%). Distribution of semiologies revealed that motor seizures were the most common type across all age groups (p>0.05). Forty-five seizures were classified as dialeptic seizures and were the second most common seizure type (12%), followed by 26 special seizures (7%), 10 auras (2.7%), and one autonomic seizure. Subclassification of semiologies showed that simple motor seizures were the most frequent type (49%), followed by complex motor seizures (29%).

Subclassification of 184 simple motor seizures revealed that 106 were tonic seizures and constituted more than half of the simple motor seizures (57.6%), followed by 38 clonic seizures (20.6%), and 29 versive seizures (15.7%). Five epileptic spasms were noted; myoclonic and tonic-clonic seizures, three each, were also rare. Of 29 seizures with versive semiology, 14 appeared at ictal onset, the remaining 15 appeared during the course of the seizures. Subclassification of 107 complex motor seizures revealed that 68 were automotor seizures (63.5%), 30 were hypermotor seizures (28%),

Table III. Incidence of Each Semiology, and Frequency of Occurrence at Ictal Onset According to Semiological Seizure Classification in Pediatric Patients with Ictal Video-EEG Recordings.

	Total number of semiologies n (%)	Occurring as initial semiology n (%)
Aura	10 (2.7)	10(100)
Somatosensory	5 (1.4)	5(100)
Olfactory	1 (0.3)	1(100)
Abdominal	2 (0.5)	2(100)
Visual	2 (0.5)	2(100)
Autonomic seizure	1 (0.3)	1(100)
Dialeptic seizure	45 (12)	38(84)
Motor seizure	291 (78)	134 (46)
Simple motor seizure	184(49)	92(50)
Myoclonic	3(0.8)	3(100)
Epileptic spasm	5(1.4)	5(100)
Tonic-clonic	3(0.8)	2(66)
Tonic	106(28.4)	55(52)
Clonic	38(10)	13(34.2)
Versive	29(7.7)	14(48)
Complex motor seizure	107(29)	42(41)
Hypermotor	30(8.4)	15(50)
Automotor	68(18.2)	23(34)
Gelastic	9(2.4)	4(44)
Special seizure	26(7)	23(88.4)
Atonic	9(2.4)	9(100)
Hypomotor	10(2.7)	9(90)
Astatic	4(1)	4(100)
Akinetic	1(0.3)	1(100)
Aphasic	2(0.5)	0
Total	373(%100)	206(55.2)

and 9 were classified as gelastic seziures.

Of the 45 dialeptic semiologies, 38 were seen at ictal onset (84%). Eight patients had seizures, which consisted merely of dialeptic semiology. According to ictal EEG data, six of them had absence seizures and two had focal seizures.

Subclassification of 26 special seizures showed that most of them were hypomotor (10/26) and atonic (9/26) seizures, followed by four astatic seizures, two aphasic seizures and one akinetic seizure. A total of ten hypomotor semiologies were observed in ten patients. Nine of these patients had intellectual disability and one patient was one year old. Hypomotor seizures presented as the single semiology in eight of them.

Ten seizures were classified as auras; somatosensory in 5, abdominal and visual had two in each, and olfactory in one. Aura was not seen in patients who were younger than two years. Aura, atonic and astatic semiologies were seen only as the first semiology of the seizures.

Discussion

We studied 183 pediatric patients with ictal recordings and evaluated a total of 373 semiologies according to SSC. The majority of the semiologies were motor seizures (78%); distribution of semiologies revealed that motor seizures were the most common type across all age groups ($p>0.05$). In adults, patients with intractable epilepsy mostly suffer from temporal lobe epilepsy, whereas almost half of the patients in the pediatric population have extratemporal epilepsy which may account for the predominance of motor seizures in studies involving children[10]. Furthermore, in infants and young children, temporal lobe epilepsy may present with prominent motor manifestations mimicking extratemporal epilepsies[11]; however most of our patients were older than 5 years of age. Further classification of main semiologies showed that simple motor seizures were the most frequent (49%). The most common subtypes of simple motor seizures were tonic (57.6%), clonic (20.6%) and versive (15.7%) seizures. Previous reports on SSC in children showed similar results with simple motor seizures as the leading semiology; by Kim et al.[7] and Hirfanoglu et al.[8], seeing 47.6% and 55.7% respectively. The most common simple motor subtype was tonic seizures in the study of Kim et al.[7], as seen in our series, however Hirfanoglu et al[8]. found versive seizures to be the most frequent.

The second most common semiological subtype was complex motor seizures (29%), consisting predominantly of automotor semiology. Automatisms were seen at all ages in children with changing repertoire and complexity by maturation[11].

Most of our patients had structural brain abnormalities as the underlying cause for their epilepsy; therefore generalized seizures such as myoclonic seizures and tonic-clonic seizures were infrequent in our series, the sum of which was 1.6% of all semiologies.

Dialeptic semiology was the second major heading following motor seizures, and constituted 12% of all semiologies. Hirfanoglu et al.[8] found dialeptic seizures to be 21.1% of all semiologies; however their series represented an older age group compared to our series. Also, etiological profiles of their patients were not reported. Majority of dialeptic semiologies were seen at ictal onset (84%). We had 8 patients who merely had dialeptic semiology; EEG data were compatible with absense seizures in six and focal seizures in two. Although SSC provides a better description of clinical behavior of seizures, it may not always be helpful in differentiation of focal and generalized seizures[12].

Aura was found only as an initial semiology in our study as reported before in children[7]. Aura is described as a seizure that produces no objective signs, and may occasionally include altered behavior[5]. Auras may be very challenging to define and classify in childhood, as physicians are able to distinguish auras only if the patient tells about the sensorial experience. In the present study, aura was not seen in young patients, as expected, due to the inability to express their auras. Kim et al.[7] concluded that although older children felt and could express auras, 25% of them could not specify their auras.

Hypomotor seizures are a new concept proposed by SSC[5]. In patients with focal epilepsy, hypomotor seizures are seen most frequently in temporal and parietal lobe epilepsy[13,14]. The main manifestation of these

seizures is a decrease or cessation of motor activity; the term is used in patients in whom consciousness cannot be evaluated during or after the seizure as in newborns, infants and children under 3 years; and patients with intellectual disability[4,14]. In our series, a total of 10 patients showed hypomotor semiology and nine of them had intellectual disability and the remaining patient was an infant.

Hamer et al.[9] 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. Kim et al.[7] and Hirfanoglu et al.[8] found that more than half of the seizures showed two or more semiologies in a seizure, thus exhibited seizure evolution involving different areas (the mean ages of their cohorts were 7.7 years, and 10.6 years, respectively). In our series 54% of seizures had more than one semiological subtype, and showed evolution of the clinical behavior of the seizure (mean age 9.5 ± 4.7 years). We did not find significant differences for seizure evolution when comparing patients 5 years and younger with patients older than 5 years; which might be due to the small number of infants in our series.

We had few patients with epileptic spasms, which could again be due to the small number of infants in our series; patients with astatic and akinetic seizures were also rare. Nordli et al.[15] 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. Hamer et al.[9] reported four types of semiology (epileptic spasm, clonic, tonic and hypomotor) to be seen in children who were under 3 years of age. They concluded that video-EEG monitoring and neuro-imaging may be critical for clarifying the focal and generalized nature of epilepsy in infants[9].

The etiological causes of our patients include, developmental abnormalities of the CNS (29.5%), perinatal insults (15.3%) and primary tumors of the CNS (8.1%). Our patients are a selected population of patients with epilepsy who were admitted for long term video-EEG monitoring in a tertiary referral center, and majority of them suffered from intractable epilepsy. A meta-analysis of publications from 1990 to March 2008 indicated that, cortical dysplasia (23–78%) and tumors (17–38%) are the most common syndromes, followed by neurocutaneous disorders, hemispheric syndromes (Rasmussen's encephalitis, hemimegalencephaly), perinatal injury, epileptic encephalopathy, hypothalamic hamartomas, and mesial temporal sclerosis, in children with epilepsy who underwent surgery[16].

The data on advantages, usefulness, applicability and feasibility of the SSC for children are sparse. Kim et al.[7] described all ictal features with SSC, but not all seizures could be classified by SSC in childhood epilepsies. Hirfanoglu et al.[8] concluded that their findings suggest SSC to be an applicable and reliable method for daily use in outpatient clinic. On the other hand, Parra et al.[17] found SSC is more suitable in the setting of a tertiary epilepsy center with an epilepsy surgery program according to the data from their pediatric and adult patients. In addition, they found better inter-observer agreement in International Classification of Seizures than SSC[17]. Inter-observer agreement was not evaluated in the present study.

Semiologic seizure classification was proposed for definition of symtomatogenic zone which further helps in delineation of the epileptogenic zone; therefore it provides an efficient tool for presurgical evaluation of patients with intractable epilepsy[13,18]. More recently, Loesch et al.[19] suggested that seizure semiology may be particularly helpful in patients with non-lesional temporal lobe epilepsy who were considered for invasive evaluations. However, SSC is not without limitations[13]; there may be significant inter-rater variability, particularly when observers come from different epilepsy centers, which may define symptoms and signs differently. In addition, SSC is based on definition of symptomatogenic zone and may fail to localize/lateralize the epileptogenic zone. Focal and generalized seizures may not be differentiated merely based on semiology and require additional information such as EEG data[13].

The current study presents clinical and etiological profiles of the patients, in addition to seizure semiology. In summary, about half of our patients had early onset seizures,

more than half of our patients suffered from developmental delay/intellectual disability, the majority had structural brain lesions as the underlying cause, the majority of them received more than one AED, and more than one third underwent epilepsy surgery, suggesting that most of our patients had intractable epilepsy with comorbidities.

In conclusion, we found the SSC system applicable for children admitted to VEMU. However, in addition to detailed clinical evaluation, video-EEG monitoring and neuroimaging studies are necessary to provide complementary information for evaluation of children with epilepsy.

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