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Localization of pediatric seizure semiology

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HIGHLIGHTS

- On examination of seizure semiology and EEG localization we did not find a one-to-one relationship.
- Different seizure semiologies relate to specific brain regions, but this relationship is not exclusive.
- Our findings support the recent separation of seizure semiology and epilepsy localization by the ILAE.

ABSTRACT

Objective: The aim of this study was to evaluate the relationship between semiology of seizures in children and adolescents to the corresponding EEG localization.
Methods: Charts of 225 consecutive pediatric epilepsy patients undergoing Video-EEG monitoring (VEM) over 2 years were reviewed. Seizure semiology recorded during VEM was classified according to ILAE seizure semiology terminology and EEG localization, and analyzed based on onset as defined by the EEG data (generalized, frontal, temporal, parietal, occipital or multilobar).
Results: A total of 1008 seizures were analyzed in 225 children (mean age 8.5 years, range 0–20), with 50% boys. Auras and seizures with automatisms arose predominantly from the temporal lobes ($p < 0.001$). Tonic, clonic and tonic-clonic seizures had most commonly generalized onset ($p < 0.001$). Hypomotor seizures were most frequently seen from the frontal lobes ($p < 0.001$). Hypermotor seizures had most commonly temporal lobe or multiple lobe onset ($p < 0.001$ and $p < 0.05$ respectively). Atonic, myoclonic seizures and epileptic spasms had almost exclusively a generalized onset ($p < 0.001$).
Conclusions: Different seizure semiologies relate to specific brain regions, with overlap between focal and generalized semiological seizure types, as identified electrographically.
Significance: Semiology of seizures can provide important information for epilepsy localization, and should not be overlooked, especially in patients undergoing pre-surgical evaluation. Separation of clinical seizure description and EEG findings may be useful, in particular when only incomplete information is available. i.e. during the first office visit.

1. Introduction

The main goal of resective epilepsy surgery is the complete resection of the epileptogenic zone, i.e. the "area of cortex that is indispensable for the generation of epileptic seizures" (Rosenow and Luders, 2001). The pre-surgical work-up aims at the estimation of the epileptogenic zone, and consists of a multi-step evaluation of clinical data, including seizure semiology, electrographic (EEG) recordings, neuroimaging, functional imaging and other neurophysiological tools, and neuropsychological testing. It is well accepted that the availability and use of information on seizure semiology during the pre-surgical workup improves lateralization and localization of the epileptogenic zone (Loddenkemper and Kotagal, 2005). Data on semiology is gathered historically (i.e. from the patient's description, and observer reports of seizures if available), and by further analysis during video-EEG recordings.

The relevance of clinical localizing signs and seizure semiology has also been recognized by the ILAE. A descriptive terminology of ictal semiology has been introduced to better describe and recognize semiological features, which may be of localizing or lateraliz-

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ing significance (Berg et al., 2010; Blume et al., 2001). Similarly, proposals for classification of epilepsy have also included such considerations (Berg et al., 2010; Loddenkemper et al., 2005; Kellinghaus et al., 2004; Engel 2001; Luders et al., 1998).

The available information on the localizing significance of different semiological features has mostly relied on selected case series and retrospective analysis of surgical data. To our knowledge, no systematic analysis of the corresponding EEG data in seizures of different semiology has been reported. The aim of this study was to evaluate the relationship between semiology of seizures in children and adolescents to the corresponding EEG localization.

2. Methods

2.1. Patient selection

We undertook a retrospective review of charts of 380 consecutive patients undergoing Video EEG monitoring (VEM) at our pediatric epilepsy monitoring unit. We excluded 155 patients due to one or more non-epileptic events recorded during VEM (regardless of the presence of epileptic events) (79), missing data (26), no recorded seizures (8), and age >21 years (42). A total of 225 patients were thus included.

2.2. Continuous video-EEG monitoring

Patients underwent VEM for a period of time ranging from 1 day up to 9 days. During the admission, antiepileptic drugs (AEDs) were tapered as needed, in a patient-specific pattern, taking into account seizure frequency and severity as well as prior history of status epilepticus. All scalp-EEG recordings were performed using the 10–20 international system of electrode placement, with additional placement of anterior temporal electrodes. Video recordings were obtained by digital closed-circuit video cameras and continuously monitored during day-time and night-time by EEG technologists. The EEG and video data were interpreted by at least two clinical epileptologists/clinical neurophysiologists.

2.3. Seizure semiology analysis

The semiology of all archived seizures was classified according to the ILAE seizure semiology terminology (Blume et al., 2001; Luders et al., 1993). In addition, the term "hypomotor seizures" was included in our classification. When the seizure evolved into other clinical seizure types, the first semiological seizure phase (onset) was used for analysis. Subclinical EEG seizures were not included in the analysis. All seizure videos were analyzed by two independent clinical epileptologists/clinical neurophysiologists, who were blinded to the patient's clinical history. Assignment to different seizure semiologies was completed by consensus with a third neurophysiologist in rare cases of disagreement. Data on circadian occurrence of seizure patterns has been submitted in a separate manuscript, but relationship of seizure semiology to EEG localization data has not been submitted for publication elsewhere.

2.4. EEG analysis

For the purposes of the present study, two independent clinical epileptologists/clinical neurophysiologists undertook a second analysis of all EEG data. Both EEG reviewers were blinded to the clinical history and seizure video. Data analysis was based on lobar localization (i.e. frontal, temporal, parietal, occipital, generalized), as determined by the ictal EEG recording. When seizures involved two or more lobes at onset, or when the localization of onset was not clear (including when record was obscured by significant myogenic/movement artifact), these were classified under a separate combined category (i.e. multilobar). When there was no concordance between the two EEG reviewers on EEG seizure onset, data were reviewed by a third reviewer (less than 5% of seizures) whose decision was decisive.

2.5. Statistical analysis

Statistical analysis was performed with binomial testing using SPSS 16.0 for Macintosh computers (SPSS Inc, Chicago, IL).

3. Results

3.1. Demographics and clinical characteristics of patients

A total of 1008 seizures were analyzed in 225 children. The mean age was 8.5 years ± 5.7 (range 0–20 years), with 50% boys. The mean VEM duration was 4 days ± 1.88 (range 1–9 days). The mean number of AEDs per patient was 1.99 ± 0.97 (range 1–5). Details of seizures and epilepsies of the 225 patients are presented in Table 1. In most cases, the etiology of epilepsy was unknown (132 of 225 cases, 59%). The most common seizure localization onset was generalized, seen in 374 of 1008 seizures (37%), in 67 of the 225 patients (30%).

3.2. Semiology and EEG localization of seizure onset

Distribution of EEG seizure onset per different lobes and semiology is presented in Table 2. Auras and seizures with automatisms [or seizures characterized by (oromanual) automatisms] arose predominantly from the temporal lobes (60/152 and 44/82 respectively, both $p < 0.001$). Tonic and clonic seizures had most commonly generalized onset (84/201 and 35/91 respectively, both $p < 0.001$), and tonic-clonic seizures had always generalized onset (24/24, $p < 0.001$). About 42% of hypomotor seizures (26/62) were seen from the frontal lobes ($p < 0.001$). On the contrary, hypermotor seizures had most commonly onset from the temporal lobe or from multiple lobes ($p < 0.05$ and $p < 0.001$, respectively). Atonic, myoclonic seizures and epileptic spasms had almost exclusively generalized onset (47/55, 50/66, 33/39, respectively, $p < 0.001$). There were five gelastic seizures and all had generalized EEG onset. Dyscognitive seizures had most commonly generalized (44/78) or

Table 1
Characteristics of seizures and epilepsy.

Seizures per patient (*n*)	1–13 (mean 4.5; median 4; SD 2.45)
EEG seizure Localization (n of patients)	
Generalized	67
Frontal	29
Temporal	29
Parieto-occipital	9
Multilobar	91
EEG seizure Localization (n of seizures)	
Generalized	374
Frontal	118
Temporal	183
Parieto-occipital	84
Multilobar	249
Etiology of epilepsy	
Unknown	141
Symptomatic (Structural/metabolic/genetic)	84
Specific epilepsy syndromes	
West syndrome	6
Lennox-Gastaut syndrome	2
Juvenile Myoclonic Epilepsy	2
Childhood Absence Epilepsy	2
Benign focal epilepsy of childhood	1