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Biceps electromyography in dialeptic and automotor seizures with and without secondary generalization

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HIGHLIGHTS

- This study analyzed biceps muscle activity during the course of automotor and dialeptic seizures.
- A new seizure evolution with a generalized tonic–unilateral clonic pattern was noted in dialeptic seizures.
- A prominent uni- or bilateral spindle-shaped increase of muscle tone could serve as predictor for generalizing seizures.

ABSTRACT

Objective: Localization of seizure onset during presurgical video-EEG monitoring is indispensable for successful epilepsy surgery. Sometimes analysis of ictal EEG and video fails to identify this zone. Therefore, this study explored the hypothesis that ictal EMG recordings contribute to the lateralization or localization of focal epilepsy.
Methods: All patients with automotor or dialeptic seizures with or without secondary generalization were prospectively included during presurgical video-EEG monitoring over a 5 years study period. We analyzed characteristics of ictal biceps EMG and compared the results to EEG and video findings.
Results: 79 patients with 185 seizures were included (51.9% male; 73.5% automotor and 26.5% dialeptic seizures; 24.3% seizures secondarily generalized). Even in dialeptic seizures, muscle tone increased bilaterally within seconds after EEG seizure onset (66.7%) without clinical movements. Bilateral "spindle-shaped" EMG activity during the automotor phase predicted secondary generalization in 88.7%. Increase of muscle activity in the contralateral side of the body in the beginning of the secondarily generalized tonic–clonic phase was detected in 78.1% after automotor seizures whereas this phenomenon was less pronounced after dialeptic seizures (69.2%). 38.5% of dialeptic seizures evolved into generalized tonic–unilateral clonic seizures.
Conclusion: Ictal EMG recordings provide lateralizing signs especially in secondarily generalized automotor seizures. In addition, the study suggested that secondary generalization in automotor seizures is determined early already during the automotor phase. Dialeptic seizures can evolve only unilaterally into a tonic–clonic seizure while the other side of the body remains tonic.
Significance: Ictal biceps EMG can provide further information regarding lateralization of epileptic seizures.

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1. Introduction

Epilepsy is one of the most common chronic neurological disorders and affects about 0.5% of the world population (Fisher et al., 2005). About 30% of patients have seizures despite anticonvulsive treatment. In this group epilepsy surgery can be considered after presurgical epilepsy evaluation. However in some patients, analysis of ictal EEG and video fails to identify the seizure onset zone.

There is evidence that ictal electromyogram (EMG) contributes to the understanding of the pathophysiology of seizures (Hamer et al., 2002). In patients with focal clonic seizures, polyspike–wave complexes in the precentral gyrus were responsible for cloni in EMG recordings shown by simultaneous recordings of invasive EEG and surface EMG (Hamer et al., 2003). Patients with progressive myoclonus epilepsies revealed increased beta activity in the frontocentral area which started immediately before occurrence of myoclonic twitches and therefore was considered to be the precipitating EEG correlate (Panzica et al., 2003).

It is unclear whether ictal EMG recordings can help in the clinical presurgical epilepsy evaluation to design a successful resective strategy. Therefore, this study explored the hypothesis that ictal biceps EMG recordings contribute to the lateralization or localization of the epileptogenic zone and may give new insights in the course of epileptic seizures. In this study, we focused on frequent seizure types, such as dialeptic or automotor seizures with or without secondary generalization (Luders et al., 1998).

2. Patients and methods

2.1. Subjects

In this prospective study, we included consecutive patients with dialeptic or automotor seizures (Luders et al., 1998) with or without secondarily generalized seizures from 1998 to 2005. All patients were admitted to our video-EEG monitoring unit for presurgical epilepsy assessment.

Inclusion criteria were a minimum of one dialeptic or automotor seizure with or without secondarily generalization during the monitoring. If patients had several seizures, only the first three seizures were included in the study. There was no age restriction.

Exclusion criteria were technical difficulties compromising the polygraphic analyses such as dislocated electrodes during seizure, absence of electroencephalography (EEG), electromyography (EMG) or ictal video and refusal of continuous surface EMG electrodes which were part of the standard monitoring setup in our unit and performed as standard of clinical care.

Epilepsy syndrome diagnoses were based on seizure semiology (Luders et al., 1998), interictal and ictal EEG recordings and high resolution MRI of the brain.

2.2. Methods

Video-EEG monitoring was performed using 21 scalp electrodes according to the International 10/20 system. In some patients, additional sphenoidal electrodes were inserted. The EMG electrodes (silver/silver chloride) were placed over the muscle belly of both biceps brachii muscles in a distance of 5 cm–7 cm. The electrodes were fixed with collodion and gauze bandages. Resistance was checked regularly and was kept below 5 kΩ. The signals were sampled with a high pass filter of 0.5 Hz and a low pass filter of 70 Hz, which was the maximal frequency window of the video-EEG monitoring system. Sampling frequency was 200 Hz.

In secondarily generalized tonic–clonic seizures, onset of the tonic phase was defined as beginning of ramping up EMG activity or the sudden more than twofold rise of the interference pattern as compared to the EMG during the preceding dialeptic or automotor seizure. Onset of clonic phase was defined as pause of EMG activity for at least 100 ms.

2.3. Statistics

Results are given as mean and standard deviation (SD). We used the non-parametric chi-square test and Mann–Whitney-*U* test for dependent samples to test for group differences. As this study was exploratory, the significance level was set to $p < 0.05$ and the *p*-values were interpreted as descriptive measures rather than results of hypothesis testing. No adjustment for multiple testing was performed.

3. Results

We included 79 consecutive patients with 185 seizures (41 male (52%); 47 seizures with generalization; 25.4%). Temporal lobe epilepsy was diagnosed in 51 patients (64.6%). The epileptogenic zone was left-hemispheric in 65 patients and 97 seizures (52.4%) and right-hemispheric in 37 patients and 71 seizures (38.4%). Presurgical monitoring could not lateralize the epileptogenic zone in 7 patients and 17 seizures (9.2%) (see Table 1).

3.1. Automotor seizures

In nearly all automotor seizures (101/102 (99%)), EMG activity increased at seizure onset and was unilateral in 89 cases (87.3% Fig. 1; $p < 0.001$). Increase of EMG amplitude contralateral to EEG seizure onset was detected in 46 seizures (45.1%) with a mean latency of 1.78 s ± 3.23 s, ipsilateral increase was detected in 43 seizures (42.2%; latency: 5.82 s ± 9.57 s). In 13 seizures (12.7%) EEG and EMG onset was synchronous. There was no repetitive muscle activity in the EMG recordings of the biceps muscles during manual or oral automatisms as seen in the ictal video. In 87.5% of secondarily generalized automotor seizures, "spindle-shaped" EMG activity was noted during the automotor phase ($p < 0.001$, Fig. 1, Table 2). This was true for only 7.8% in automotor seizures without generalization. Spindle-shaped activity was characterized by coniform increase and decrease of muscle activity. The spindle was unilateral in 29.4% and bilateral in 58.1% in generalized sei-

Table 1
Patient characteristics.

	Male	Female	Total
Patients in total	41	38	79
Seizures[1]			
Autom. seizures without gen.	60	42	102
Dial. seizures without gen.	15	21	36
Sec. gen. automotor seizures	16	18	34
Sec. gen. dialeptic seizures	3	10	13
Age			
5–20	8 (19.5%)	6 (15.8%)	14 (17.8%)
21–40	19 (46.3%)	20 (52.6%)	39 (49.4%)
41–60	14 (34.2%)	11 (28.9%)	25 (31.6%)
>60	0	1 (2.7%)	1 (1.2%)
Epilepsy syndrome			
Temporal lobe epilepsy	21 (51.2%)	20 (52.7%)	41 (51.9%)
Mesial temporal lobe epilepsy	6 (14.6%)	4 (10.5%)	10 (12.7%)
Frontal lobe epilepsy	2 (4.9%)	3 (7.9%)	5 (6.3%)
Temporooccipital epilepsy	2 (4.9%)	0	2 (2.5%)
Other epilepsy syndromes[2]	10 (24.4%)	11 (28.9%)	21 (26.6%)

[1] In some patients dialeptic as well as automotor seizures with and without secondary generalization could be recorded.

[2] Included are symptomatic multifocal epilepsies and left- and right hemispheric epilepsies without further localization.