Changes in Sympathetic Activity Associated with Epileptic Seizures

Ming-Zher Poh[1,2], Tobias Loddenkemper, MD[3], Claus Reinsberger, MD, PhD[4], Nicholas C. Swenson[2], Shubhi Goyal[2], Joseph R. Madsen, MD[5], Rosalind W. Picard, ScD[2].

[1]Harvard-MIT Division of Health Sciences and Technology, Cambridge, MA, United States, 02139; [2]The Media Laboratory, Massachusetts Institute of Technology, Cambridge, MA, United States, 02139; [3]Division of Epilepsy and Clinical Neurophysiology, Department of Neurology, Children's Hospital Boston, Boston, MA, United States, 02115; [4]Department of Neurology, Division of Epilepsy, Brigham and Women's Hospital, Boston, MA, United States, 02115. [5]Neurosurgery, Children's Hospital Boston, Boston, MA, United States, 02115

RATIONALE: Modulation in skin conductance, referred to as electrodermal activity (EDA), reflects purely sympathetic activity of the autonomic nervous system. Several cortical structures with recognized seizure potential have connections with autonomic centers and electrical stimulation of such structures can induce changes in EDA (Mangina CA et al. *Int J Psychophysio* 1996;22:1-8). We hypothesized that epileptic seizures can induce changes in EDA.

METHODS: We continuously recorded EDA of pediatric patients with epilepsy admitted to the long-term video-telemetry monitoring unit at Children's Hospital Boston using custom designed wrist-worn EDA sensors. Video-EEG recordings were retrospectively reviewed by an epileptologist blinded to the EDA data to determine seizure semiology, ictal onset and offset times on EEG, and EEG localization. EDA recordings were low-pass filtered (1024 points, Hamming window, cutoff frequency of 3 Hz) to reduce motion artifacts. For each seizure, the resulting change in EDA amplitude (difference between response peak and response onset value) was calculated. The recovery time was calculated as the time from the response peak to the point where EDA fell below 37% of the response amplitude. EDA parameters between complex partial seizures (CPS) and secondarily generalized tonic-clonic seizures (2°GTCS) were compared using the Wilcoxon rank sum test.

RESULTS: Eight patients (one female) between ages 7-20 years were included in this study. The total recording time analyzed from all patients was 23 days. 17 epileptic seizures (nine CPS and eight 2°GTCS) were evaluated. All seizures were associated with an increase in EDA. The EDA amplitude was significantly higher ($p < 0.01$) after 2°GTCS (18.86 ± 13.14 μS) compared to CPS (3.68 ± 4.92 μS). The EDA recovery time was also significantly longer ($p < 0.05$) after 2°GTCS (6.68 ± 6.28 min) compared to CPS (2.49 ± 1.93 min).

CONCLUSION: We report of spontaneous seizure-induced elevation in EDA in patients with epilepsy. Our pilot series suggests that a massive activation of the autonomic sympathetic nervous system occurs during 2°GTCS. This may be a sign of autonomic instability that may play a role in the pathophysiology of sudden, unexpected death in epilepsy. Further studies regarding the relationship between peri-ictal EDA and heart rate variability, a risk factor for sudden cardiac death, are currently underway.

Table 1. Clinical characteristics of patients with epilepsy

Case	Sex/Age/Epilepsy duration (yrs)	Seizure focus	Seizure type	Length of recording analyzed (days)
1	M/20/4	Left anterior temporal	CPS, 2°GTCS	4
2	M/13/8	Left fronto-temporal	CPS	4
3	M/15/-	Right central	CPS	2
4	F/7/3.5	Left frontal	CPS	1
5	M/20/10	Right frontal	CPS	1
6	M/17/1	Bifrontal	CPS, 2°GTCS	3
7	M/9/9	Left frontal	CPS, 2°GTCS	4
8	M/16/15	Left fronto-temporal	CPS, 2°GTCS	4

CPS = complex partial seizure; 2°GTCS = secondarily generalized tonic-clonic seizure

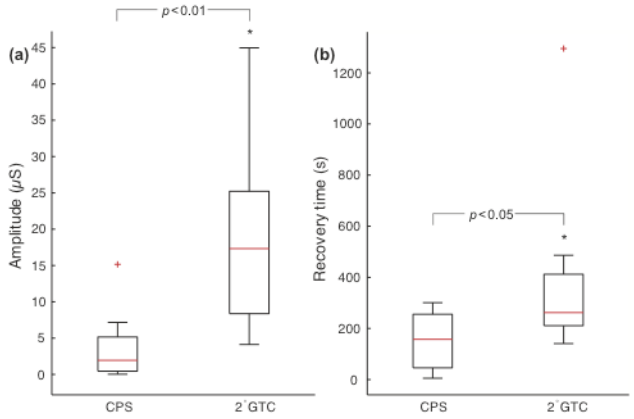

Figure 1. Comparison of peri-ictal EDA parameters between complex partial seizures (CPS) and secondarily generalized tonic-clonic seizures (2°GTCS). (a) EDA amplitude (b) EDA recovery time