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Background intracranial EEG spectral changes with anti-epileptic drug taper

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ABSTRACT

Objective: Previous studies have revealed a surprising decrease in spike counts and Teager energy between on- and off-AEDs states during intracranial EEG (icEEG) monitoring. Here, we expand the measures evaluated to icEEG power and frequency band power.
Methods: Two icEEG epochs, on- and off-AEDs, each 1 h in duration, were studied for each of 21 unselected adult patients. Spike counts, Teager energy and total power were evaluated for each electrode contact. Power was also evaluated for delta (0–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–25 Hz), gamma (25–55 Hz) and high (65–128 Hz) frequency bands.
Results: A decrease in power accompanies AED taper and the previously reported decrease in spike counts and Teager energy. The decrease in power was underpinned by a spatially widespread and broadband decrease in power in delta through gamma frequency bands with maximum decrease in the lowest frequency bands. An increase in high-frequency power was observed in some patients.
Conclusions: There is a decrease in spike counts, Teager energy and power from on- to off-AEDs state during intracranial monitoring. The decrease in power is spatially widespread and broadband including power in the delta through gamma frequency bands.
Significance: The decrease in cortical activity with AED taper suggests that seizure generation during intracranial monitoring may not be mediated solely by poorly regulated cortical excitation.

1. Introduction

Modern surgical approaches and technology have improved our ability to acquire intracranial EEG (icEEG) with improving spatial and temporal resolutions. Newer electrode types, image guided electrode placement, decreased complications and several other factors have led to an increase in spatial sampling of intracranial studies. In the time domain, current equipment permits acquisition and storage of days to weeks of continuous icEEG with sampling rates up to several kHz. The advances have improved the studies which can be performed in this setting, with considerable attention being placed on studies of seizure prediction and seizure onset localization. There are many challenges to quantitative analysis of icEEGs. Amongst these are several aspects of the setting of intracranial monitoring which remain poorly understood, including the effect of electrode placement, AEDs and patient state. One important aspect of this setting is that the longitudinal nature of data acquisition permits a study design where the subjects can serve as their own control. Properly chosen epochs and conditions while controlling for several other factors allow studies where specific questions can be addressed and novel insight can be obtained.

AED taper is performed during icEEG monitoring of patients undergoing intracranial monitoring for epilepsy surgery because it results in an increased propensity for seizures. A comparison of background icEEG between on- and off-AEDs states should reveal changes which accompany this increased propensity for seizures. We have recently reported a decrease in spike counts and Teager energy, both surrogate measures of cortical excitation, accompanies AED taper during icEEG monitoring (Spencer et al., 2008; Zaveri et al., 2009). In this study we extend the analysis to a wider set of measures to include total power and band power.

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2. Methods

2.1. Subjects

Twenty one adult patients, from a consecutive series of 23 patients, evaluated with intracranial EEG and video monitoring for resective epilepsy surgery at the Yale-New Haven Hospital were included in this study. One patient was excluded because the patient was drowsy throughout the on-AEDs state and a second patient was excluded because of excessive noise contamination of the icEEG record during times of interest. The average age of the patients was 33 and included 9 women and 12 men (see Table 1).

2.2. Intracranial EEG monitoring protocol

We refer to the seizure onset area as the region of initial seizure expression (RISE). The RISE was identified through icEEG monitoring by an independent clinical team as part of the routine care of these patients. The icEEG monitoring protocol followed is similar to that employed at other epilepsy centers (Spencer et al., 2009) and includes neuroimaging with both CT scan and MRI after electrode placement to allow precise localization of intracranial electrode contacts. Monitoring is typically begun on the day following surgery to place electrodes. AED taper is performed to increase the likelihood for observing seizures. Based on the literature, and our own experience, we do not withdraw barbiturates

Table 1
RISE location and AEDs during on- and off-AEDs states, and the number of days between these epochs. The RISE location was medial temporal in 7, neocortical in 12, and poorly localized in 2 patients. The patients were on multiple AEDs at admission and during the course of the study one or more AEDs were tapered. The abbreviations used for AEDs are: CBZ – carbamazepine, CZP – clonazepam, GPN – gabapentin, LEV – levetiracetam, LTG – lamotrigine, OXC – oxcarbazepine, PB – phenobarbital, PHT – phenytoin, TPM – topiramate, VPA – valproic acid and ZNS – zonisamide.

Patient	Seizure onset location	Sample 1 AEDs	Sample 2 AEDs	Days between measurements
1	L anterior medial frontal	CBZ 800	CBZ 800	3
		LEV 2250	Discontinued	
		ZNS 500	Discontinued	
2	L medial temporal	OXC 1800	Discontinued	8
		GPN 1800	Discontinued	
		LEV 500	Discontinued	
		VPA 250	Discontinued	
3	L superior parietal	CZP 1.5	CZP 1.5	6
		PHT 200	Discontinued	
		CBZ 1600	Discontinued	
4	L medial temporal	OXC 900	Discontinued	8
		PHT 330	Discontinued	
5	L medial temporal	ZNS 400	ZNS 400	2
		CBZ 600	CBZ 300	
		PHT 100	Discontinued	
6	R anterior superior lateral temporal	LTG 400	LTG 400	4
		CBZ 800	Discontinued	
7	Neocortical onset, unlocalized	LTG 300	LTG 50	5
		CBZ 1200	Discontinued	
		TPM 75	Discontinued	
8	Bilateral medial temporal	CBZ 1200	CBZ 600	3
		ZNS 200	Discontinued	
9	R inferior temporal	OXC 1950	OXC 1200	5
		LEV 4000	LEV 1200	
10	Neocortical onset, diffuse	CBZ 1200	Discontinued	9
		GPN 600	Discontinued	
11	R medial temporal	TPM 400	Discontinued	8
		LEV 1500	Discontinued	
12	R Parietal	PB 150	PB 150	2
		CBZ 600	CBZ 400	
		LTG 300	Discontinued	
13	R inferior temporal	LEV 6000	LEV 4000	5
		LTG 750	LTG 350	
		OXC 3600	OXC 1800	
14	R occipital pole	OXC 300	Discontinued	5
		ZNS 400	ZNS 100	
15	L medial occipital	CBZ 1400	CBZ 200	4
		GPN 1800	Discontinued	
16	L parieto-occipital	PHT 1250	Discontinued	2
		VPA 400	Discontinued	
		ZNS 200	ZNS 200	
17	R inferior posterior temporo-occipital	LEV 1000	Discontinued	7
		OXC 3600	OXC 1350	
18	R medial temporal	LEV 1500	Discontinued	6
		PHT 530	PHT 260	
		ZNS 100	Discontinued	
19	L medial temporal	CBZ 600	Discontinued	3
		VPA 400	VPA 200	
		ZNS 400	ZNS 200	
20	R parietal	CBZ 1200	CBZ 600	3
		TPM 300	Discontinued	
21	L posterior inferior temporal	LTG 275	LTG 275	2
		OXC 225	Discontinued	