

Imaging Epileptic Seizures in a Rat Model using Electric Impedance Tomography and its Clinical Implications

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Abstract: The potential of Electric Impedance Tomography (EIT) for localising seizure foci was examined in a rat model of epilepsy. The known seizure focus was successfully imaged, which appeared as a transient (~10 ms) decrease in impedance during spikes – due to the opening of ion channels, followed by a gradual increase in impedance as cells swelled.

1 Introduction

Epilepsy is the commonest neurological condition which is characterized by recurrent, unpredictable seizures due to synchronized neuronal firing. Of those with chronic epilepsy, 20-30% will not respond to antiepileptic drugs, though many can be treated surgically if a seizure focus can be localized [1]. EIT was previously used in an animal model to image the seizure focus, as accompanying cell swelling increases brain impedance [2]. Changes in impedance due to neuronal activity have been presented before [3]. Here, the first-ever impedance images of both the fast neural response (due to ion channel opening) as well as the slower impedance signal (due to movement of water from extra- to intra-cellular space) during epileptic seizures in rats are presented.

2 Methods

30-channel subdural grid electrodes were implanted over the somatosensory cortex of 9 adult Sprague-Dawley rats under general anaesthesia. Epilepsy was induced by intracortical injection of 4-aminopyridine, picrotoxin or penicillin. Impedance was recorded with a custom-made programmable current source and an amplifier (ActiveTwo AD-box, Biosemi, Netherlands). An AC current with a frequency of 1.7 kHz and 60 μ A amplitude was injected between differ-

ent pairs of the electrode grid. Sample results are shown (Figure 1).

3 Conclusions

Following interictal epileptic spikes, there were reproducible fast neural impedance decreases of $-0.26 \pm 0.09\%$ (mean \pm SD, 3562 interictal spikes) 7 ms preceding the peak of the interictal spikes, and impedance increases of $0.57 \pm 0.32\%$, starting 50 ms after each interictal spike and lasting up to 2 s with no difference between seizure models. For seizures, there were significant peak impedance increases of $2.21 \pm 1.16\%$ (201 seizures in total) but no consistent impedance decreases. The impedance changes occurred focally around the injection site and were consistently imaged with a resolution of ~0.4 mm. Impedance measurements could potentially be used to localize seizure onset zones and track seizure spread in human epilepsy patients.

References

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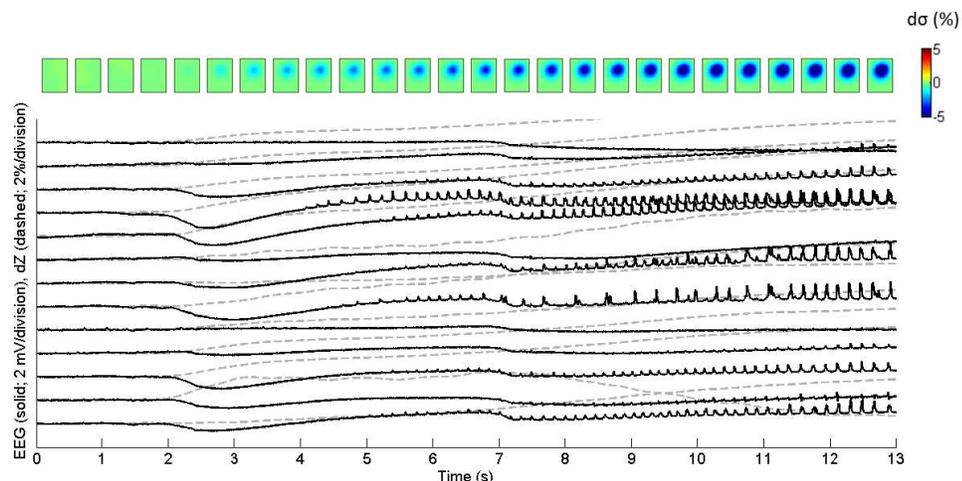


Figure 1: Example of an induced seizure. Solid line: EEG signals, dotted line: corresponding impedance changes. Top row: corresponding EIT images showing focal onset and spread of seizure (depth of slice = 1 mm).