

Combined EEG/MEG and optimized transcranial direct current stimulation for non-invasive diagnosis and therapy of focal epilepsy

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Abstract—We show in a double-blind sham-controlled N-of-1 trial of focal epilepsy that individually targeted and optimized multi-channel transcranial direct current stimulation (mc-tDCS) can significantly reduce epileptic activity.

I. INTRODUCTION

In focal epilepsy, seizures can often not adequately be controlled with anticonvulsant drug treatment, necessitating new forms of diagnosis and therapy. Combined electroencephalography (EEG) and magnetoencephalography (MEG) source analysis has the potential to improve the localization of the epileptogenic zone [1]. It's results may open the way to new treatment options, including targeted non-invasive tDCS [1,2]. As shown in standard 2-patch tDCS [3,4], significant reductions of epileptic activity can be expected. In this work, we will for the first time use for this purpose our recently developed Distributed Constrained Maximum Intensity (D-CMI) mc-tDCS technique [2].

II. METHODS

Our patient is a 20-year-old female with epilepsy since the age of 14. Seizure semiology was described as distributed thinking and inability to speak or follow a conversation, without any motor symptoms and without impairment of awareness. The patient did not become seizure free despite treatment with multiple anticonvulsant drugs. From T1- and T2-weighted magnetic resonance image (MRI) data we first constructed a realistic finite element method (FEM) volume conductor model of the patient's head, including skull defects, calibrated skull conductivity and white matter conductivity anisotropy. We then used this head model in combined EEG/MEG source analysis for localizing the irritative zone from sub-averaged interictal epileptiform discharges (IEDs) [1]. D-CMI [2] was then used for the

optimization of an mc-tDCS montage. A total amplitude of 4 mA was applied twice for 20 minutes, with a pause of 20 minutes in between, for five consecutive days. An Acti-Sham montage (adjacent leads have opposite polarities) was applied with the same regimen as treatment. There was a washout of 5 weeks between the two stimulation weeks.

III. RESULTS

Targeted D-CMI mc-tDCS led to a highly significant reduction in IED frequency after treatment with median 66% ($55.8\% \pm 11.2\%$, $p < 0.00001$), while Acti-Sham did not ($p > 0.05$). The IED source amplitude was decreased by 76% after treatment with D-CMI mc-tDCS while it was only reduced by 29% after treatment with Acti-Sham. Side effects entirely pertained to transient sensations. With regard to ictal activity, the patient experienced a seizure with decreased severity during the stimulation week.

IV. DISCUSSION

This proof of principle shows high therapeutic potential for combined MEG/EEG-targeted and D-CMI optimized mc-tDCS and paves the way for a group study in focal epilepsy.

ACKNOWLEDGMENT

We thank Andreas Wollbrink and Christian Glatz for technical assistance and Luca-J. Bombardelli, Hildegard Deitermann, Juliana Gericks, Gabriele Kemper, Ute Trompeter, Pia Wenge and Karin Wilken for their help with the EEG/MEG/MRI and tDCS data collection.

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*This research was supported by the Bundesministerium für Gesundheit (BMG) as project ZMI1-2521FSB006, under the frame of ERA PerMed as project ERAPERMED2020-227 PerEpi.

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