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TU-114. Transcranial electrical stimulation generates electric fields in deep human brain structures

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Introduction: Transcranial electrical stimulation (TES) is a non-invasive tool to modulate brain activity by injecting a low intensity current on the scalp through 2 or more electrodes. Its basic principle has been widely explored in the past decades through in-vitro, in-silico, and animal in-vivo studies and clinical studies in humans. TES mechanism of action is related to the electric field (EF) generated on the target and its strength is critical to induce a potential neuromodulation. Some studies (n = 4) have estimated the in-vivo intracerebral EF in humans relying mainly on electrocorticographic recordings, which require a craniotomy impacting EF distribution, and did not investigate deep brain structures. Here we aim to measure in-situ the electric field generated in human in-vivo directly in deep brain structures by leveraging on intracerebral-EEG investigation (SEEG) in drug resistant epilepsy patients.

Methods: Eight drug resistant epilepsy patients who underwent presurgical evaluation and who had SEEG electrodes were included in the study. We performed tACS at 7 different frequencies (in 1 patient), 15 montages (in 1 patient) and 2 intensities (0.5mA and 1mA in 6 patients). TACS-induced voltages were measured on intracerebral contacts at the exact same frequency of the stimulation. EF magnitudes were calculated by subtracting tACS-induced voltages on adjacent intracerebral contacts and divided by the distance separating them.

Results: Overall, EF was measured on 1145 SEEG contacts. At the intensity of 1 mA, mean EF magnitudes of 0.21, 0.17 and 0.07 V/m were found in the amygdala, hippocampus, and cingulate gyrus, respectively. An average of 0.14 ± 0.07 V/m was measured in these deep brain structures. Mean EF magnitudes in these structures at 1Hz were 11% higher than at 300Hz (± 0.03 V/m). Global electric field decreased as a function of the depth following an inverse-square law. Montages which generated the maximum EF in amygdalae were T7-T8 and in the cingulate gyri were C3-FT10 and T7-C4. EF magnitude has a strong linear relationship with the stimulation intensities ($R^2 \geq 0.98$ for a pure linear distribution with a slope at 2). **Conclusion:** TES at low intensities (1mA) can generate an EF in deep brain structures, irrespective of stimulation frequency. EF magnitude has a quasi-perfect linear relationship with the stimulation intensity which is an important information for future EF gross estimation in clinical application.

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