Numerical dosimetry of the neuroprotective effect of PEMFs through a semi-specific modeling: comparison between an active and a placebo patient.

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The application of low intensity and low frequency pulsed electro-magnetic fields (LF-PEMFs) may represent a neuroprotective approach for the treatment of acute (i.e., within 48 hours from the insult) ischemic strokes [1]. Several in-vivo and in-vitro studies have suggested the interaction between the low frequency and low energy (1 mT - 3.5 mT) PEMFs with the A2a and A3 adenosine receptors, that are involved in the human body’s anti-inflammatory and immune responses to events such as ischemic stroke [2]. Consequently, an open-label, study was carried out to evaluate PEMFs safety and tolerability on 6 patients with acute ischemic stroke [3]. A preliminary dosimetric analysis on the aforementioned study assessed a novel approach that employs semi-specific modeling of the patient’s head [3]. Furthermore, with this new dosimetric methodology it was possible to build a dose-response curve in a fast and reliable mode, opening the way for the use of a similar approach to other “electroceutical” applications. Such previous results laid the groundwork for the I-NIC project: a multicentric, randomized, placebo-controlled, double-blind study, in which approximately 124 patients are under recruitment with the aim to clarify the effectiveness of the PEMFs therapy [4]. In this study, we present the dosimetric results on one active and one placebo patient recruited for the I-NIC study, with the aim to compare the different trend of the two dose-response curves. The methodological procedure to conduct the dosimetry and attain the dose-response curves followed the one assessed in [3] and is here briefly recalled. For each patient, the semi-specific model is built in the Sim4Life environment (ZTM Zurich MedTech AG) by precisely placing the 3D model of the ischemic lesion at the time of the insult (i.e. pre-) inside a detailed generic head model. The first one is obtained from each patient’s MRI scans, whereas the second one is the Virtual Population 84-year-old male model Glenn (ViP, V.3). Finally, the stimulating coil is reproduced in the simulation environment with a single turn rectangular wire with no thickness, placed close to the head, with the ischemic volume centered along the coil axis. A 3D model of the ischemic lesion at the 45 days follow-up is obtained as well (i.e. post-) to correlate the B-field intensities with the evolution of the lesion. Only the pre-treatment ischemic model is considered in the dosimetric problem of PEMFs stimulation which was solved with the FEM quasi-static solver in Sim4Life. To quantify the ischemic volume progression after the PEMFs treatment, B-field values (Bthr) in a range from 1 mT to 2 mT were selected and the amount of pre-treatment volume (Vpre) exposed to a B ≥ Bthr, as well as the corresponding post-treatment volume (Vpost) were evaluated for each patient. The ratio Vpost/Vpre was computed with respect to Bthr to attain the dose-response curve. Results showed that the volume ratio in one representative placebo patient ranges from 122% up to 150% at 2 mT. Conversely, in one representative active patient, the ratio is always under 100%, addressing a possible reduction of the post-treatment lesion, and its curve decreases for higher Bthr values. Such result may suggest the absence of a correlation between the volumetric evolution of the ischemia with the values of magnetic field in placebo patients, and the presence of a descending trend of the dose-response curve in the active patients. Once that the patients’ recruitment will be completed, it will be possible to clarify the effectiveness of the PEMFs treatment.


