Reversibility of Cortical Functions during Acute Ischemic Stroke via Sensorimotor Stimulation

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***Abstract*— Studying cerebrovascular functions after ischemic stroke explicates brain plasticity. This study reports an innovative combination of electrocorticography (ECoG) recordings and functional photoacoustic microscopy (fPAM) to investigate cortical functions after photothrombotic stroke in rats, treated with electrical forepaw stimulation as treatment. The cortical functions are assessed over the selected ischemic region via somatosensory-evoked potential (SSEP) and evoked hemodynamic response. The treatment is applied to the forepaw contralateral to occlusion using 2 mA pulses initiated 0, 1, or 2 hours post-ischemia to determine optimal onset timing. Results demonstrated that our treatment administered within 2 hours post-ischemia induced reversed cortical functions, owing to collateral circulation, suggesting effective recovery.**

I. Introduction

Acute ischemic stroke is a leading cause of death and disability; thus, novel neuroprotective therapies are being developed for. This study investigates a prospective clinically-translatable method of enhancing stroke recovery by forepaw electrical stimulation. Using a photothrombotic stroke model, we studied the effect of stimulation as a 120-min treatment at different onset timings post-ischemia. By the ECoG-fPAM system, we probe pre- and post-ischemic cortical functions evoked by stimulation.

II. Materials and Methods

30 male Wistar rats were used in this study. 7 screw electrodes were secured in the skull for SSEP recordings. A 6 × 3 mm cranial window was made while keeping the dura intact. The cortical blood vessels under the open-skull window were imaged *in vivo* by fPAM at λ_{570} [1]. Focal acute ischemic stroke was induced by photothrombosis technique. The targeted distal branch of the middle cerebral artery was illuminated with 0.5 mW, 532 nm continuous wave laser light following tail-vein-injection of the photosensitizer Rose Bengal. A total of 4 groups were used in this study. The control group involved photothrombotic ischemic stroke induction but no forepaw stimulation treatment. In the other 3 experimental groups, stimulation treatment was onset at different timings as follows: Immediately following stroke (group 1), 1 hr post-stroke (group 2) and 2 hrs post-stroke (group 3). To monitor functional changes in HbT, CBV, and SO_2, two optimized wavelengths (λ_{560} and λ_{570}) were employed [1]. The SSEP was sampled at 1 kHz, pre-amplified, and band-pass-filtered. The P1 and N1 components of the SSEP were analyzed along with changes in peak-amplitude and peak-latency from the extracted and averaged SSEP.

III. Results

The fPAM-measured CBV, HbT and SO_2 changes are measured in this stroke study. Control group showed no significant HbT. In experimental groups, significant HbT changes were observed in the arterioles contralateral to the stimulated forepaw. Significant reduction in R_{HbT}, R_{CBV} and $-R_{\mathrm{SO_2}}$ was observed after ischemia. The post-stroke P1 amplitude of the three groups (Fig. 1A) dropped by 40 % and increased to 10% below baseline after treatment. However it plummeted to 60 % (group 2) and 90 % (group 3) with treatment continued beyond 2.5-3 hrs. N1 amplitude follows a similar trend. P1 and N1 peak-latency changes had an analogous outcome in all groups, as shown in Fig. 1B with an increase of 10-20 % post-stroke. P1 and N1 latency recovered to original value in group 1 whereas it increased with treatment beyond 2.5 hrs post-ischemia, in groups 2 and 3.

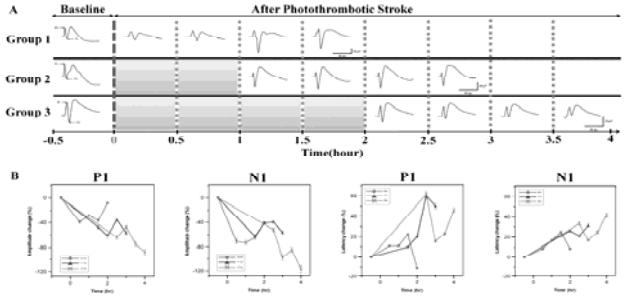

Fig. 1 Experimental results of different groups are showed in this figure. (A) SSEP changes before and after stroke. (B) The corresponding parameters changes of SSEP components after photothrombotic ischemic stroke induction.

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