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The brain modulation effect of focused ultrasound

Ting-Yu Chang
Chang Gung Memorial Hospital at Linkou, Taiwan

Co-administration of microbubbles and focused ultrasound can elicit cavitation-induced enhancement of vascular permeability across blood-brain barrier. In the present research, we proposed that focused ultrasound can be applied to deliver noninvasive and reversible brain modulation dubbed as brain modulation induced by focused ultrasound (BMFU). We hypothesized that BMFU could induce short-term suppression of local brain activity and its effect is reversible. We also seek to find an optimized ultrasound intensity can induced substantial BMFU effects without eliciting noticeable brain damage such as microscopic hemorrhage. To this end, we present BMFU homogenously to one hemisphere of SD rats and analyzed its effectiveness by observing the change of somatosensory evoked potential (SSEP). The SSEP was elicited by electrical forepaw stimulation and was recorded by epidural electrodes implanted on the scalp. The rats were assigned into one of two experiment groups and control group. In the experimental groups, the protocol of BMFU was 0.4 MPa for 60 s or 0.3 MPa for 120 s (burst duration = 10 ms, pulse-repetition frequency = 1 Hz). The rats in the control group received BMFU of 0.4 MPa for 60 s without microbubble injection.

The results showed that BMFU of 0.4 MPa induced the most robust suppression of SSEP and the effects could last for 60 minutes ($p<0.05$). Follow-up SSEP 1 and 3 hours, and 1 and 3 days after BMFU showed a complete recovery of SSEP responses. The same trend was observed in the 0.3MPa group but not found in the control group. Histological analysis showed that BMFU of 0.4 MPa induced substantial microscopic hemorrhage but BMFU of 0.3 MPa induced minimal or no microscopic hemorrhage. The results support that BMFU can induce localized suppression of brain activity evidenced by decrease of SSEP in the targeted hemisphere. The present study proposes a novel non-invasive, reversible and localized brain modulated method which is suitable for a variety of neurophysiological experiments and clinical applications.

taiwan.changty@gmail.com