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저강도 경두개 초음파 자극을 통한 글림패틱 기능의 향상 및 뇌 노폐물의 배출

Low-Intensity Transcranial Ultrasound in Glymphatic Function and Brain Waste Removal

Abstract(영문):

Low-intensity transcranial ultrasound has emerged as a promising strategy to enhance cerebrospinal fluid (CSF) circulation and facilitate clearance of neurotoxic metabolites. We investigated its effects on CSF dynamics, amyloid-beta ($A\beta$) clearance, and underlying mechanisms.

Magnetic resonance imaging after cisterna magna injection of gadolinium revealed accelerated CSF transport with earlier and stronger peaks in ultrasound-treated groups. Fluorescence imaging of deep cervical lymph nodes confirmed increased drainage of labeled $A\beta$, and hippocampal immunofluorescence demonstrated significant reduction of deposits following repeated sonication.

Mechanistically, ultrasound reorganized aquaporin-4 (AQP4) distribution, enriching AQP4 at perivascular astrocytic end-feet and increasing the M23/M1 isoform ratio, accompanied by transient transcript downregulation. Safety assessments indicated no neuronal damage or abnormal neuronal activation caused by ultrasound sonication.

These findings demonstrate that ultrasound accelerates CSF circulation and promotes $A\beta$ clearance by modulating AQP4 localization, supporting its translational potential for Alzheimer's disease.

Brief Biosketch (간단한 이력, 연구/대외활동 소개,국문/영문)

I am a Postdoctoral Researcher at SonocareLab, Sungkyunkwan University. My research centers on developing ultrasound-based therapeutic systems for neuromodulation and glymphatic regulation in neurodegenerative diseases. I have published in *Advanced Science*, *Annals of Biomedical Engineering*, *IEEE Transactions*, and received multiple best awards in academic conferences. In 2023, I was selected as a research scholar at the University of Southern California, where I actively collaborated with faculty and students on international therapeutic ultrasound projects.