Optoacoustic imaging of mouse cortical vessels using skull-implanted miniature ultrasound hydrophones

A. Kurnikov[1], M. Loginova[1,2*], Lei Xi[3], P. Subochev[1]

[1]Federal research center A. V. Gaponov-Grekhov Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russia
[2]Privolzhsky Research Medical University, Nizhny Novgorod, Russia
[3]Southern Technological Univercity, Shenzhen, China
[*]marialoginova96@ya.ru

Brain disorders such as stroke and neurodegeneration are closely linked to changes in cortical blood vessels and neurovascular coupling. Photoacoustic microscopy is attractive for this field because it combines optical absorption contrast with ultrasonic readout and can map vascular structures without exogenous labels. However, the mouse skull remains a serious acoustic barrier: it attenuates, refracts, and distorts broadband photoacoustic waves, which limits the sensitivity and reproducibility of transcranial measurements.

This poster describes a strategy for improving photoacoustic detection from the mouse cerebral cortex using two customized transcranial ultrasonic transducers. Optical access is provided by a conventional cranial window. A focused laser beam is scanned through this window and excites photoacoustic signals in cortical vessels, while the acoustic response is detected by miniature transducers positioned outside the skull or, in later configurations, partially implanted through small skull openings. The long-term goal is to develop implantable ultrasonic detectors that can remain mechanically stable with respect to the skull and improve the signal-to-noise ratio of longitudinal brain imaging experiments.

At the present stage, the work is focused on physical modeling and phantom validation rather than on a completed in vivo protocol. We simulate propagation of broadband photoacoustic waves through the mouse skull and analyze how skull thickness, detector position, and the presence of drilled openings influence the detected signal. In parallel, we perform phantom experiments with excised mouse skull bones. The laser is scanned through an artificial cranial window, and the generated ultrasound is recorded either through intact skull regions or through prepared openings using customized hydrophones and compact transducers. These experiments are expected to define the acoustic penalty introduced by the skull, identify detector geometries suitable for transcranial listening, and guide the next stage of the project: implantation-compatible ultrasonic detectors for more sensitive photoacoustic monitoring of cortical vasculature.

Keywords: biophotonics, photoacoustics, ultrasound, brain.

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-45-02127).