Title: Translating Focused Ultrasound Neuromodulation into Clinical Practice for Epilepsy

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Abstract:
Focused ultrasound (FUS) has emerged as a promising non-invasive neuromodulation modality for patients with drug-resistant epilepsy, owing to its ability to modulate neuronal activity with high spatial precision. This technology enables targeted intervention within epileptic networks without the need for surgical incisions, ionizing radiation, or implanted devices. In particular, low-intensity focused ultrasound can selectively alter neuronal excitability and suppress epileptiform activity, offering the potential to reduce seizure burden through modulation of pathological network connectivity rather than irreversible tissue ablation.

Recent preclinical and early clinical studies have demonstrated the feasibility and safety of transcranial focused ultrasound neuromodulation, with minimal adverse effects and no significant structural tissue injury observed in human investigations. Emerging clinical evidence further suggests that ultrasound-based neuromodulation may reduce seizure frequency and provide therapeutic benefit in selected patients with drug-resistant epilepsy. These findings position focused ultrasound as a novel circuit-based therapeutic approach that complements and expands existing neuromodulation strategies.

This lecture will review the fundamental biophysical mechanisms underlying focused ultrasound neuromodulation and its effects on neuronal excitability and epileptic network dynamics. We will discuss current clinical evidence, safety considerations, patient selection, and neuroimaging-guided targeting strategies. Finally, we will address key translational challenges and future directions, including personalized targeting, closed-loop neuromodulation, and integration into routine clinical practice. Focused ultrasound represents a transformative, incisionless neuromodulation technology with the potential to redefine therapeutic strategies for epilepsy through precise, non-invasive modulation of pathological brain circuits.