INTRODUCTION

Focused ultrasound

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THE use of ultrasound has a long and rich history in medicine. Its versatility as both a diagnostic and therapeutic tool has been recognized for decades, with interest in potential intracranial applications extending to the 1940s and earlier. It was then that ultrasound's "property of focusability... [suggested] the possibility that an optimum combination of wave length, intensity and exposure might be found which would produce a focal destruction in the depths of tissue, without injuring the intervening layer."⁴

Our ability to interact directly with dysfunctional brain circuits has evolved significantly over the last half century. Advances in brain imaging, stereotaxy, surgical technology, and neurophysiology have driven the neuromodulation field from crude art to a precise and image-guided field and from a largely exploratory endeavor to a hypothesis-driven subspecialty. Focused ultrasound, in many ways, personifies these advances, merging the diagnostic power of high-resolution imaging with the ability to interact directly on submillimetric scales with brain pathology.

Although there exists a growing number of applications and variations, at its core focused ultrasound involves the concentration of acoustic energy onto discrete brain regions, with resultant tissue effects determined both by wave properties, such as frequency, as well as interactions with constituent brain components and vasculature, such as circulating microbubbles. High-frequency MR-guided focused ultrasound (MRgFUS) has emerged as a promising modality to generate lesions in the brain, without the need for open neurosurgery. MRgFUS has thus recently become an option for patients with essential tremor, and is currently under investigation for other indications, such as Parkinson's disease and obsessive-compulsive disorder, for which ablative approaches have proven effective.^{1,3} Low-frequency ultrasound, coupled with circulating microbubbles, permits reversible opening of the blood-brain barrier and is a promising approach for the delivery of therapeutic compounds in a broad range of conditions, including cancer and neurodegeneration.^{2,5} Although external high-intensity focused ultrasound guided by MRI is most commonly

described, external and internal devices with and without MRI are also in preclinical development for neurological indications.

The articles contained in this issue of *Neurosurgical Focus* represent the state of the art in focused ultrasound research, covering the spectrum from the technical to the clinical. We thank the authors for their valuable contributions, as we take stock of current work in the field and shed light on future directions, promises, and challenges.

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