High Intensity focused ultrasound for tumor

Neurooncology, in particular, has become a major area of interest because High Intensity focused ultrasound (FUS) offers a multifaceted approach to the treatment of brain tumors. FUS has the potential to generate cytotoxicity within tumor tissue, both directly via thermal ablation and indirectly through radiosensitization and sonodynamic therapy; to enhance the delivery of therapeutic agents to brain tumors by transiently opening the blood-brain barrier or improving distribution through the brain extracellular space; and to modulate the tumor microenvironment to generate an immune response. In a review, Hersh et al., describe each of these applications for FUS, the proposed mechanisms of action, and the preclinical and clinical studies that have set the foundation for using FUS in neuro-oncology [1)].

Kullervo Hynynen, a Finnish-born ultrasound and MRI physicist, and Ferenc Jolesz, a Hungarian-born neurosurgeon and visionary of image guided surgery, have joined forces at Radiology, Brigham & Women's Hospital, Boston, and they have taken every step to realize the vision above, in highly successful collaboration with the industry (GE, InSightec, TxSonics). The sophisticated transcranial HIFUS instrumentation, supported by profound research data from experimental animals and by the clinical experience from extracranial HIFUS targets (breast fibroadenoma, uterine fibroid), is now coming to a phase I clinical trial in cerebral metastases. It remains to be seen whether transcranial HIFUS will find applications in diffuse gliomas such as (a) thermal ablation of selected areas of glioma tissue, opening the blood-brain-barrier for therapeutic constructs to enter selected areas, or activating such constructs in desired areas. The prophecy of Dr. Jolesz, “this technology will put neurosurgeons out of business”, may not fulfill during our lifetime [2)].

Ongoing clinical trials involving patients with brain tumors, Alzheimer's disease, or epilepsy, and pre-clinical work involving stroke and hydrocephalus have the potential to significantly expand the possible indications for transcranial FUS in the future [3)].

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Focused ultrasound (FUS) has the potential to generate cytotoxicity within tumor tissue, both directly via thermal ablation and indirectly through radiosensitization and sonodynamic therapy; to enhance the delivery of therapeutic agents to brain tumors by transiently opening the blood-brain barrier or improving distribution through the brain extracellular space; and to modulate the tumor microenvironment to generate an immune response. In a review, Hersh et al., describe each of these applications for FUS, the proposed mechanisms of action, and the preclinical and clinical studies that have set the foundation for using FUS in neurooncology [5)].

Gillies et al. describe the experience of using HIFU to ablate sacral chordoma in four patients with advanced tumours. Patients were treated under general anaesthetic or sedation using an ultrasound-guided HIFU device. HIFU therapy was associated with a reduction in tumour volume over time in three patients for whom follow up scans were available. Tumour necrosis was reliably demonstrated in two of the three patients. We have established a national trial to assess if HIFU may improve long-term outcome from sacral chordoma, details are given [6].

The goal of a research was to develop an ultrasound imaging-guided robotic HIFU ablation system for tumor treatment. The system integrates the technologies of ultrasound image-assisted guidance, robotic positioning control, and HIFU treatment planning. With the assistance of ultrasound image guidance technology, the tumor size and location can be determined from ultrasound images as well as the robotic arm can be controlled to position the HIFU transducer to focus on the target tumor. After the development of the system, several experiments were conducted to measure the positioning accuracy of this system. The results show that the average positioning error is 1.01 mm with a standard deviation 0.34, and HIFU ablation accuracy is 1.32 mm with a standard deviation 0.58, which means this system is confirmed with its possibility and accuracy [7].

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