AbstractID: 10040 Title: The Role of MRI-Guided High-Intensity Focused Ultrasound in Cancer Therapy

Ultrasound is best known for its imaging capability in diagnostic medicine. However, there have been considerable efforts to develop its therapeutic use. High-Intensity Focused Ultrasound (HIFU) has long been known to offer the potential of precise "Trackless lesioning" but has only recently with the current high quality methods of medical imaging, become a practical possibility for clinical treatment.

Focused ultrasound uses ultrasound energy for tissue ablation. When the sound waves are focused to a small volume in the body, the intensity is high and the temperature at the focal point rises to 70-95 ºC, high enough to ablate the tissue. Proper treatment design will ensure that the energy density will be high at the focal point but low at other locations, and thus avoiding damages to nearby normal tissues.

The volume of ablation (lesion) following a single HIFU exposure is small and will vary according to the transducer characteristics, but it is typically cigar shaped with dimensions in the order of 1-3 mm (transverse) x 8-15 mm (along the beam axis). To ablate clinically relevant volumes these lesions must be placed side by side properly to "paint" the desired target volume.

Simply calculating an optimal treatment plan is not enough to ensure optimal outcome. Patient anatomic variability and tissue inhomogeneities have been shown to produce vastly different responses to thermal energy deposition, especially deep in the body. High quality imaging techniques can provide precise visualization and localization of the tissue damage. MR images enable the physician to localize the tumor and plan the treatment in the full 3 dimensions. Real-time MR thermometry can provide an indication of tissue damage if critical temperatures are known.

In several centers worldwide, HIFU is now being used clinically to treatment solid tumors (both malignant and benign), including those of the brain, breast, liver, kidney, prostate, bone matastases, pancreas and soft-tissue sarcoma. MRI-guided high-intensity focused ultrasound (MRgFUS) is currently commercially available for clinical applications.

Recent advances in the area of therapeutic ultrasound also involve drug delivery. Enhancement of drug delivery to tumors with HIFU has been demonstrated in animal models *in vivo*. Ultrasound emitted in short, high-energy pulses, will result in focused regional shock waves, which alter vascular and/or cell membrane permeability without permanently damaging the tissue. MR imaging can be used to place the ultrasound beam in the target area and monitor the effect of the treatment and the increased vascular permeability will allow for efficient delivery of macromolecular pharmaceutical agents to the treatment target. The mechanisms for producing the observed enhancement are thought mainly due to a non-thermal effect – the stable cavitation.

This lecture will provide an overview of MRgFUS and introduce the equipment that is commercially available for clinical applications in cancer treatment.

Educational Objectives:

1. The principles of MRgFUS
2. Advantages and limitations of MRgFUS for tissue ablation
3. Potential clinical applications of MRgFUS for cancer treatment