Noninvasive Rx of Breast Cancer by MR-guided High Intensity Focused Ultrasound

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Introduction

Local hyperthermia has been suggested for many purposes, e.g. tumor ablation, control of gene therapy, local drug delivery, heat-activated chemotherapy. Focused ultrasound (FUS) with a wavelength of about 1mm is capable of non-invasively depositing energy in a target area deep within the body without harming neighboring tissues. However, FUS energy absorption and heat conduction depend on tissue composition and physiological processes like perfusion. Hence continuous thermometry of the target area is necessary. MRI is an ideal tool for guiding FUS because of its unique temperature mapping capabilities, and its soft tissue contrast for target definition. It is now an FDA approved method for treatment of uterine fibroids, and appears very promising for tumor treatment. This presentation gives a summary of the technical developments of a MRI guided FUS platform for an impending Phase I clinical trial on breast cancer ablation.

TemperatureMRI

Temperature MRI can be used for guidance of FUS based on the temperature dependence of T1, diffusion, or the proton resonance frequency (PRF) of water. Here, fast PRF-based temperature mapping methods were employed with lipid suppression, motion artefact suppression and real time data-processing and visualization using a Philips Intera 1.5T MRI. Calculation of temperature maps and visualization of the procedure was performed on a workstation under a rapid communication protocol with the MR system.

FocusedUltrasound

Phased-array ultrasound transducers allow rapid electronic steering of the focal spot and proper focusing of the beam even for inhomogeneous tissues. A non-magnetic focused ultrasound transducer was incorporated in the bed of the MR system. MR compatible materials and filtering methods allow simultaneous MRI and high power ultrasound transmission.

AutomaticFUSheatingwithreal-timeMRIfeedbackcontrol

Automatic feedback controlled FUS guarantee a predefined temperature trajectory in the FUS focal point. Combined with regional heating based on an inside-out spiral displacement of the focal point, temperature control can be realized in the complete heated region. This unique spatio-temporal control method leads to increased safety and increased efficacy, and thus to short treatment durations.

Breastcancer,MRcompatible,FUSplatform

The technologies described above were adapted towards a specific platform for breast cancer therapy. The unique feature of this platform is the sideways FUS transmission avoiding high power US deposition towards lungs. An ellipically shaped FUS transducer with 256 elements was designed with minimized secondary lobe intensity. The patient is lying prone. The transducer is positioned under the patient bed for optimal targeting. A low intensity test shot is used for verification of the position of the focal point with respect to the tumor. Then, the therapy session is started with electronic displacement of focal point, and spatio-temporal temperature control.

Summary

A specific FUS-MRI platform was designed for breast cancer treatment. Phased array technologies, sideways FUS transmission, and spatio-temporal temperature control in the complete region of interest, were combined for a novel therapy approach with enhanced safety and afficacy. A phase I clinical trial will start soon.