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MRI-guided transurethral diagnosis and treatment of localized prostate cancer

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Abstract

Minimally-invasive, image-guided treatments for localized prostate cancer that provide local control with a low side-effect profile would have a major impact in improving disease management. Accurate localization of disease with imaging coupled with technologies capable of precise treatment could enable evolution of prostate cancer treatment from a whole gland to a more targeted approach. MRI-guided transurethral ultrasound therapy is such a technology in which high-intensity ultrasound energy is delivered to the prostate from a device inserted into the urethra. The goal of the treatment is to generate a prescribed spatial pattern of thermal coagulation in the gland. The treatment is performed in a closed-bore MR imager to obtain quantitative temperature maps during ultrasound heating of the prostate. This temperature information is used by the treatment delivery system to adapt the exposure conditions dynamically during treatment to compensate for changes in blood flow, tissue absorption and thermal conduction. Previous numerical, phantom, and canine studies have demonstrated that this approach offers a high degree of spatial treatment accuracy (±1-2 mm). Recent clinical evaluation of the technology has confirmed the feasibility of performing this treatment in humans. The desire to deliver more targeted treatments in the prostate for reduced morbidity requires accurate localization of disease, ideally with medical imaging. A unique opportunity that exists in transurethral ultrasound therapy is to generate shear waves in the adjacent prostate gland through vibration of the device. These shear waves can be imaged with MRI and quantitative stiffness maps can be calculated for localization of disease, or evaluation of the pattern of thermal coagulation in the gland. Initial experiments have been performed in phantoms and canines to explore the feasibility of this concept. This presentation will introduce the concept of transurethral ultrasound therapy and will review the results obtained with this technology. In addition the potential to combine this therapy with diagnostic approaches such as MR elastography will be discussed.

Learning Objectives:

1. Describe the role of high-intensity ultrasound therapy for prostate cancer treatment.
2. Describe the technology for transurethral ultrasound therapy
3. Explain the potential role of prostate MR elastography for prostate imaging/diagnosis using transurethral devices

4. Describe the potential of quantitative MR temperature feedback in achieving closed-loop heating in vivo, and challenges in its implementation