Accurate High-Intensity Focused Ultrasound Ablation in a Porcine Liver Model Through Integration of Real-Time Image Guidance, Robotic Navigation, and Elastographic Monitoring

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Objective

Active research into accurate, minimally-invasive, image-guided destruction of focal hepatic malignancies will expand the population of treatable patients and potentially extend survival. Our objective is to develop an accurate, real-time monitored minimally-invasive ablation system through the integration of high-intensity focused ultrasound (HIFU) ablation within a flexible needle configuration, robotic steerable active cannula guidance, and real-time elasticity monitoring.

Description of Technology and Method of Application

HIFU is an ablative therapy that utilizes therapeutic ultrasound to thermally destroy tumors. Peri-procedural image guidance is critical to effective use of this modality to both plan and monitor effective ablation. Though conventional ultrasound and MRI are most frequently used for image guidance, they are imperfect for visualization targeting. Precise control of needle placement through robotic guidance can improve targeting of therapy. In addition, improved real-time ablation monitoring using real-time elasticity imaging offers the opportunity to modify and confirm accurate delivery of therapy. In this study, we have adapted ultrasound strain imaging to provide accurate real-time image guidance for HIFU needle ablation of liver lesions.

Preliminary Results

Successful engineering of integrated precise robotically-controlled steerable active cannula needle ablator with real-time elasticity image-guidance allowed ablation of hepatic lesions in ex vivo liver models. We also showed a successful utility of guiding the ablation tool using robotic steerable active cannula in an in vivo porcine model.. Strain imaging allowed for the assessment of lesion ablation and will faciliate assessment of completion of treatment. The engineered robot-controlled acoustic ablator provided precise targeting control when coupled to real-time image guidance.

Conclusions and Future Directions

These experiments demonstrated that targeted liver ablation with HIFU is feasible and safe with homogeneous and shaped ablation sites. Robotic control of the active cannula delivery of the needle ablator allows for accurate, precise targeting in an in vivo enviroment. The ablation can be coupled with elastography which provides complementary tissue strain characteristics to determine completeness of treatment.

We intend to continue to fully integrate real-time imaging modalities with robot-controlled active cannula acoustic needle ablator for complete image-guided minimally invasive treatment of liver tumors.