MRI guided percutaneous catheter-based high intensity ultrasound thermal ablation in swine muscle and kidneys.

Ricky Tong[1], K. Pallav Kolli[1], Chris Diederich[2], Vasant Salgaonkar[2], Viola Rieke[1], Eugene Ozhinsky[1], Maythem Saeed[1], Loi Do[1], Steve Hetts[1], and Mark Wilson[1]
[1]*Radiology, UCSF, San Francisco, CA, United States,* [2]*Radiation Oncology, UCSF, San Francisco, CA, United States*

<u>Target audience</u>

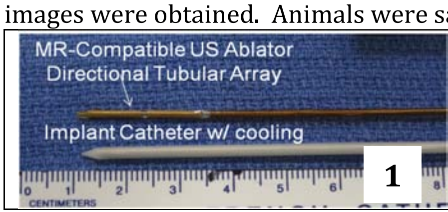
Any physicist or interventional radiologist who is interested in developing or using MR image-guided therapy for ablation treatment.

<u>Purpose</u>

While surgical resection remains the definitive therapy in many solid organ tumors, loco-regional therapies, including percutaneous ablation, are increasingly used to achieve local disease control in non-surgical candidates. The goal of this study was to investigate the use of percutaneous high intensity ultrasound ablation in swine tissue under MR guidance. MR thermometry was used to monitor real time temperature changes during ablation.

<u>Methods</u>

MR-compatible ultrasound applicators consisted of two tubular transducer elements (0.75 mm radius, 10 mm length) with an operating frequency of 7 MHz. Transducer elements were independently powered and deposited energy in a highly collimated manner within a 20 mm heating length and with a 180° or 360° angular expanse (Figure 1). In ex-vivo experiments, swine muscle was placed within a 3T scanner, and MR thermometry was acquired to visualize temperature changes during ablation (Figure 2). For in-vivo experiments, plastic percutaneous implant catheters (13-gauge) were inserted into porcine kidneys under real-time sonographic guidance. Ultrasound applicators were then deployed within the implant catheters. The experimental animals (n=2) were transported to a clinical GE 3T MRI scanner for baseline imaging, thermal ablations, and post ablation imaging. Each site was ablated for 15-20 minutes at 12-18 W/cm^2. MR thermometry was used to monitor temperature changes. Immediate post-procedural T1-contrast enhanced MR images and subsequent contrast-enhanced CT images were obtained. Animals were sacrificed 2 hours post-ablation. Kidneys were collected for histopathological analysis.



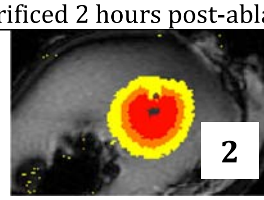
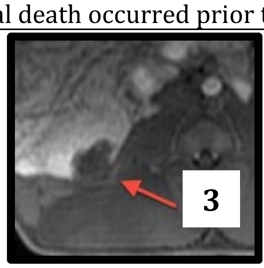


Figure 1. A photo of high intensity ultrasound applicator.
Figure 2. MRI Thermometry data shows real time temperature changes during ablation in ex-vivo swine muscle. Red, green and yellow demonstrates 20°C, 10°C and 5°C above background temperature, respectively.

<u>Results</u>

Ex-vivo experiment demonstrates the feasibility of using MR thermometry to monitor heating by MR-compatible ultrasound applicators. MR images demonstrate successful ablation in swine kidney in vivo (Figure 3). Gross specimen shows ablated tissue in the inferior pole of right kidney (Figure 4). Histology revealed irreversible thermal damage from the ablation. No animal death occurred prior to the completion of experiments.



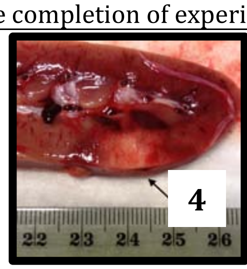


Figure 3. Axial MRI LAVA post-contrast image demonstrates hypoperfusion (red arrow) in a segment of right kidney, corresponding to the ablation zone.
Figure 4. Gross pathology demonstrates ablation zone in the inferior pole of right kidney (black arrow).

<u>Discussion</u>

Preliminary data demonstrate precise conformal thermal ablation in swine kidneys using percutaneous high intensity ultrasound catheters under MR guidance. Ablation zones can be visualized on CT and MR images. MR thermometry can be used to monitor real time temperature changes during ablation. Gross specimens confirm tissue thermal necrosis.

<u>Conclusion</u>

These preliminary data demonstrate that this technology is a potentially safe and effective tool for performing precise percutaneous thermal tissue ablation. Further experiments are underway to assess the safety and efficacy of this novel ablation technique in several organs.