AbstractID: 5191 Title: FEA and Phantom Tests of Ultrasound Temperature Maps during Thermal Therapy

Purpose: The ability to noninvasively monitor heating patterns during radiofrequency ablation therapy would provide invaluable guidance to clinicians during these procedures. We are investigating ultrasonically recorded and scaled “apparent tissue displacements”, caused by sound speed changes and tissue expansion, for generating temperature maps during ablation. This paper reports FEA simulations and experiments in novel phantoms to determine whether ultrasound can successfully record temperatures.

Method and Materials: FEA models were applied to determine the temperature distribution from a radiofrequency ablation electrode in liver. FEA analysis enabled creation of both temperature and tissue expansion maps during simulated procedures. The expansion maps in turn were combined with sound speed changes and used to model ultrasound echo data at intervals during the ablation. In addition, experimental data were acquired using a reusable slurry phantom with embedded sensors surrounding an ablation electrode. Frames of echo data were acquired using a linear array transducer during a 15-minute heating sequence. For both simulated and real data, two-dimensional cross-correlation of echo signals from successive frames yielded accumulated tissue displacements. Scaled gradients of these displacements estimate local temperatures.

Results: Temperature maps generated from simulated echo signals correspond well to the underlying temperature maps created with FEA. The zone of elevated temperatures can be easily visualized on these maps. Isothermal curves on the temperature maps may be useful in determining areas that may have incurred cell death or tissue necrosis. Preliminary results indicate good correlation between fiber optic temperature sensor measurements and ultrasound temperature measurements over $1cm^2$ ROI’s surrounding the probe.

Conclusion: Temperature maps estimated using ultrasound signals correspond well to the FEA generated temperature maps. Temperature mapping can therefore be used to visualize the zone of heating during a radiofrequency ablation procedure. This result is confirmed by temperature measurements done in an ultrasound phantom.