Thermal ablation using resistive heating by MRI steerable catheter

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Background

Steerable endovascular catheters are designed for interventional procedures performed in clinical MRI scanners[1]. The tips of these catheters are mounted with copper coils that create tiny magnetic moments upon application of direct electrical current (Figure 1). The byproduct of this process is the generation of resistive heating. Steerable catheters have been shown to create reproducible heating in a phantom comprised of bovine serum albumin (BSA) in polyacrylamide gel when sufficient power is applied.

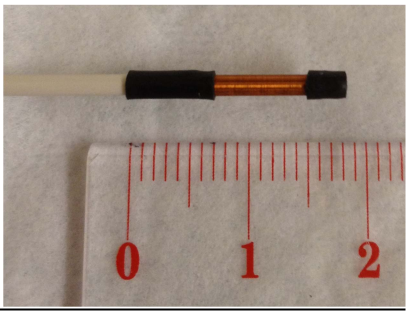

Figure 1: 5 Fr catheter with 46 AWG coil-tipped copper wire.

Purpose

The goal of this study was to create a steerable endovascular catheter that can be used to perform controlled tissue ablation under real-time MRI guidance.

Methods

5 Fr catheters were modified by winding 46 AWG copper wires around the catheter tips. A thermocouple was added to the tip of a catheter. MRI shielded cable was used to connect the catheter with the power source.

Results

We have demonstrated ablation catheters creating reproducible heating in *ex-vivo* swine liver (Figure 2). The maximum temperature achieved at the center of catheter is roughly linear with the power supplied by the power supply. At 1.62W, the tip of ablation catheter reached near 100°C. As power increases, the time to reach target temperature significantly decreases. For example, it takes less than 50 seconds to reach 60°C at 1.3W as compared to over 200 seconds at 1.0W. Visible irreversible changes of ablated tissue surrounding ablation catheter can be seen on gross specimen when the temperature of ablation catheter reaches above 60°C. Real time MRI thermometry experiment[2] immediately after ablation demonstrated visible changes in temperature profile of adjacent tissue at a distance up to 1 cm from the catheter (Figure 3). The ablation catheter is currently being tested in swine to ablate liver and kidney *in-vivo*. Visible ablation changes are seen in gross specimen.

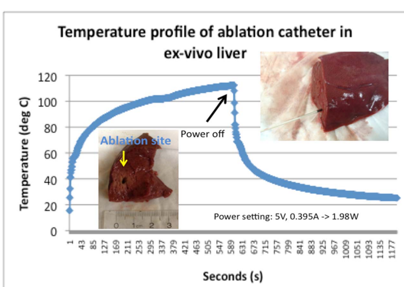

Figure 2: Temperature profile of an ablation catheter in ex-vivo liver during a heating experiment. Left lower photo demonstrates the cross sectional view of ablated area.

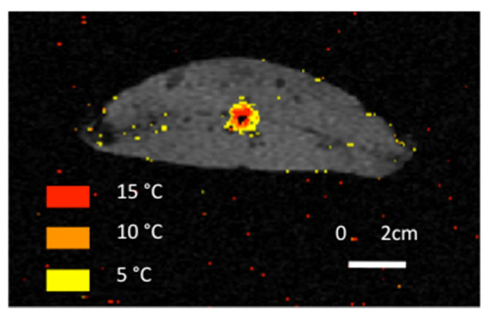

Figure 3: Real time MRI thermometry data demonstrates temperature profile of adjacent tissue immediately after ablation.

Conclusion

Steerable endovascular catheters can be used as ablation catheters via resistive heating. Real time MRI thermometry can be used to monitor temperature changes during ablation experiments.

Reference

1. Settecase F, Hetts SW, Martin AJ, et al. RF heating of MRI-assisted catheter steering coils for interventional MRI. Academic Radiology 2011 18(3): 277-285.
2. Rieke, V, Butt Paua K. MR thermometry. J Magn Reson. Imaging 2008. 27(2):376-390