MR-Guided Laser Pulmonary-Vein Ablation in Canine Models

E. J. Schmidt[1,2], V. Y. Reddy[2], G. Holmvang[2], G. Melsky[3]

[1]GE Medical Systems ASL, Boston, MA, United States, [2]Cardiology, Massachusetts General Hospital, Boston, MA, United States, [3]CardioFocus Inc., Norton, MA, United States

ABSTRACT

Thermal catheter ablation of the pulmonary veins is a common electro-physiologic (EP) procedure that can cure atrial fibrillation. Pre-operative MRI is increasingly used [1] to plan EP interventions, but does not provide real-time positional and thermal-dose information. Using a prototype MRI-compatible laser-ablation balloon catheter, MRI-guided device positioning and subsequent monitoring of heat delivery is possible.

INTRODUCTION

MRI-enabled improvement in the existing thermal ablation procedure in the pulmonary veins can be provided through determination that: 1. proper device positioning at the ostium of the vessels occurs, 2. the heating process is tracked to ensure complete circumferential ablation 3. the heated region is restricted to prevent pulmonary-vein stenosis

MATERIAL AND METHODS

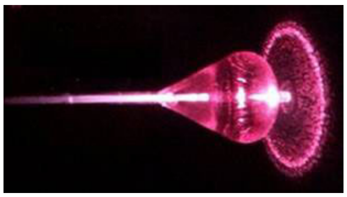

Figure 1 CardioFocus Inc. (Norton, MA) prototype MRI-Compatible laser-balloon ablation catheter inflated, and with laser directed towards distal end. The catheter has multiple lumens, including one for balloon dilation, using pressured D_2O (dark in MRI and thus a good passive marker), and one providing an optical endoscopy channel, allowing visualization of the vein interiors and thus also improving localization. Laser-ablation is a desired ablation technique, because fiber-optic delivery of light does not cause RF interference or heating. A guiding sheath was not MRI-compatible, and therefore was distanced from the ablation region.

The procedure included performing a transseptal puncture procedure followed by advancing the catheter to the proximity of the veins under X-ray fluoroscopy guidance in a normal dog. After transport into the 1.5T CV/i MRI, ECG-gated diagnostic and interventional procedures were initiated.

RESULTS AND DISCUSSION

Catheter positional manipulation and balloon dilation were performed under near real-time guidance (*I*-Drive, GE Medical Systems), as well as with optical endoscopic guidance. Figures 2 and 3 show real-time visualization of balloon deployment and dilation, and figure 4 shows T1-difference thermal imaging of the heat delivery process.

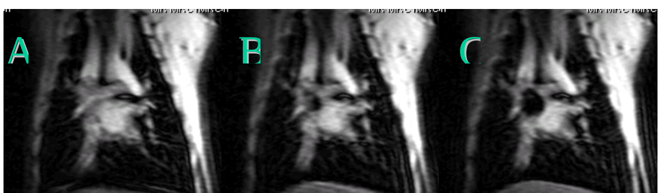

Figure 2 Near-real-time (~1 fps) coronal GRE MRI Images of laser-balloon advancement (A), deployment (B), and dilation (C). Note the large susceptibility artifact due to the non-MRI-compatible sheath in lower image. D_20-filled balloon provides a nice passive marker. TR/TE/θ=35.7ms/2.2ms/20deg, 24x24 cm FOV, 128x64, 6.0 mm slices.

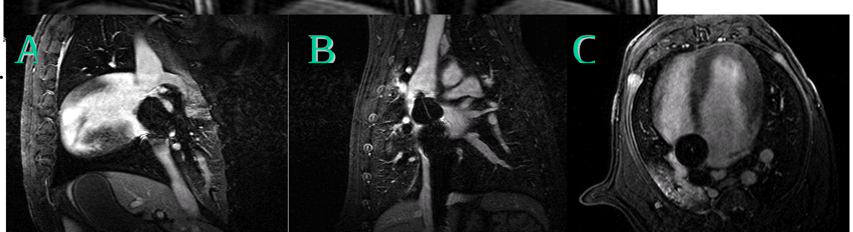

Figure 3 Breath-held high-resolution 3-D CE-MRA images of the deployed balloon, utilized to confirm balloon positioning: (A) saggital (B) coronal, (C) axial. TR/TE/θ=6.3ms/1.4ms/45deg, 24x24 cm FOV, 256x192,2.4 mm slices, 36 slices, 1 Nex.

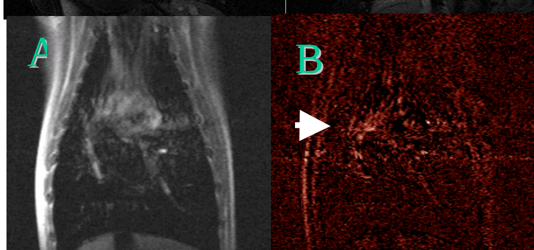

Figure 4 Thermal imaging of laser ablation (~0.5 fps): (A) coronal ECG-gated MRI image, (B) Color T1-difference map, showing bright regions (white arrow), where most of energy is delivered (towards distal and left sides of balloon). TR/TE/θ=12ms/5.0ms/30deg, 24x24 cm FOV, 256x128, 15 mm slices, 1 Nex. Images were acquired using the GE MR-Tracking interface [2].

CONCLUSIONS

MR-guided laser ablation of the pulmonary veins is feasible and provides improved procedure control. Further work will focus on improved thermal visualization.

REFERENCES

1. Malchano, Z, Reddy, VY et *Al*. Poster 4885, ISMRM 2003 2. Dumoulin CL, Souza SP, Darrow RD, MRM **2**9, 411, (1993)