VISUALIZATION OF ABLATION LESIONS BY DYNAMIC CONTRAST ENHANCED MRI

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Introduction: Intra-operative lesion visualization is important during ablative cardiac procedures whose success depends on the contiguity and transmurality of the ablation lesions. The usefulness of MR imaging of contrast kinetics for thermal lesion visualization has been already demonstrated (1-2). However, these methods rely on lengthy image acquisition and model-based curve fitting of complete data sets. Delayed enhancement (DE) methods (3-5) have also been demonstrated as a means of visualizing thermal lesions but require potentially lengthy scan times and delaying the onset of scanning after contrast agent (CA) injection. Visualizing lesions using non-contrast enhanced methods (6) deliver lower lesion-to-background contrasts. In this work we report a novel method for analyzing MRI contrast uptake dynamics, which allows robust and quick visualization of RF lesions.

Methods: Using clinical EP catheters, 16 RF lesions were created in the Latissimus dorsi muscles of 4 rabbits with power/time settings varying in the range 30-35Watt/30-45sec. T1w, T2w, SSFP, DE and dynamic contrast enhanced (DCE) MR images of the lesions were acquired 2-3 hours after the ablations. DCE images were acquired simultaneously with CA injection using RF-spoiled FGRE. 4-5 slices were imaged in 3:31-6:33 minutes with temporal resolution of 8-19 seconds. DE images were acquired using IR-SPGR, 4-10 minutes after CA injection. DE images were subtracted from a pre-contrast reference in order to improve image contrast in enhancing lesions. DCE images were post-processed on a stand-alone workstation using in-house developed algorithms and software. Analysis of the cumulative intensity difference (CID) and ratio (CIR) maps, together with their inclination maps, were calculated on each dynamic data set using only the previous and current dynamics.

Results: Our DCE analysis algorithms demonstrated differentiation between a non-perfused lesion core, a hyper-enhanced lesion border and normal tissue in a very short time following CA injection on noisy data sets (Fig. 1), which conventional semi-quantitative DCE processing methods are not well suited to. CID and CIR maps, together with corresponding inclination maps, depicted the location and extent of thermal lesions correctly and with satisfactory contrast as compared to the available standards (Fig. 2).

Discussion/Conclusions: The DCE processing methods presented here are able to visualize the lesion using less temporal information of the contrast dynamics than traditional semi-quantitative DCE analysis approaches. In addition different regions of the thermal lesion (non-perfused lesion core, hyper-enhancing border) are visible that are not well visualized using non-contrast enhanced lesion visualization methods (T2w, SSFP). The different regions are visible on delayed-enhancement images after subtraction with pre-contrast images, which can be prone to subtraction errors. Furthermore delayed enhancement imaging is only able to visualize lesions 10-15 min after contrast injection, whereas Fig 1 illustrates how clear separation between regions can be obtained in approx. 1 min using the proposed DCE processing methods. The future tissue evolution in the different regions and the ability to identify and characterize lesions more rapidly following the ablative procedure is currently under investigation.

References: **1.** J. Magn. Reson. Imaging 2003; 18: 585–598; **2.** J. Magn. Reson. Imaging 2004; 19: 329–341; **3.** Med. Phys. August 2009; 36 (8): 3521–3535. **4.** J. Am. Coll. Cardiol. 2006; 47: 370–378. **5.** Circulation 2000; 102: 698-705. **6.** Heart Rhythm 2007; 4: 208–214.

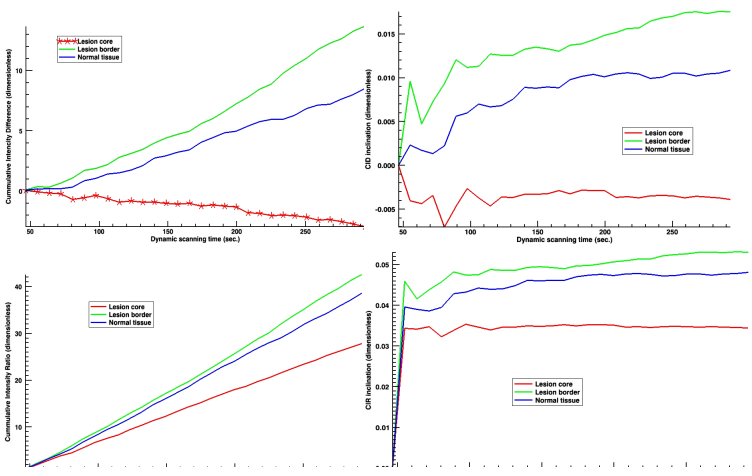

Figure 1: Time course of CID (upper left), CIR (lower left) and their inclinations (upper and lower right respectively) for a pixel in the lesion core (red line), the border region (green line) and healthy tissue (blue line). The regions are clearly differentiated within 100sec of dynamic scanning.

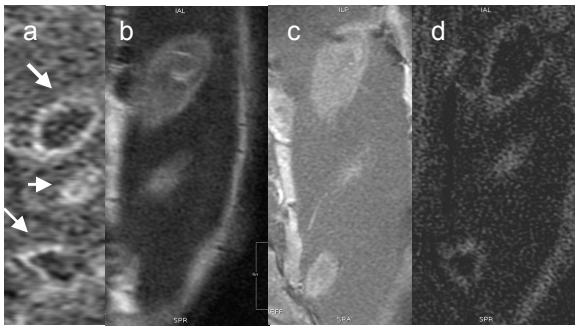

Figure 2: (a) Ablation lesion visualization (arrows) using a CID map (similar results obtained for CIR and inclination maps) obtainable in as little as one minute following CA injection, compared to (b) T2w and (c) SSFP imaging that visualize a more homogeneous lesion. (d) Delayed enhancement imaging acquired many minutes post-contrast injection demonstrate similar lesion core and border regions after subtraction with pre-contrast data.