T1-weighted DCE-MRI may be used to visualize different components of RF ablation injury in the myocardium

Sathya Vijayakumar[1,2], Ravi Ranjan[2], Nassir F Marrouche[2], and Eugene G Kholmovski[2,3]

[1]Surgical Services Clinical Program, Intermountain Healthcare, Salt Lake City, Utah, United States, [2]CARMA Center, University of Utah, Salt Lake City, Utah, United States, [3]UCAIR, Radiology, University of Utah, Salt Lake City, Utah, United States

Purpose

Radiofrequency (RF) ablation of the left ventricle (LV) and left atrium (LA) are clinically acceptable therapies for ventricular tachycardia (VT) and atrial fibrillation (AF) [1,2]. To the best of our knowledge, there is still a lack of good understanding of acute cardiac lesion physiology. It has been shown earlier that serial late gadolinium enhancement (LGE) imaging of immediately post-ablation atrial lesions can help differentiate between transient and permanent injuries based on time course of lesion enhancement [3]. However, the characterization of different tissue types immediately following an RF ablation procedure has never been addressed. **In this work, we use the contrast kinetics of myocardial tissues to identify and differentiate between the various regions of ablated tissue.**

Methods

Ten mongrel dogs (weight 25-37 kg) were ablated in the electrophysiology (EP) suite. The electro-physiologist performed RF ablations in the ventricles of the animals' heart according to protocols approved by the local IACUC. Catheter access was by means of a 12F introducer sheath placed in the right femoral vein to enable the introduction of ThermoCool catheter (Biosense Webster, Diamond Bar, CA). All MRI studies were performed using a 32 channel cardiac array (Rapid Biomedical, Germany) on a 3-Tesla MAGNETOM Verio scanner (Siemens Healthcare, Erlangen, Germany).

RF ablations in the right and left ventricle (RV & LV) were performed in the EP suite to create distinct lesions in the myocardial wall. The animals were then transported to the MRI suite. The MRI study began with localizers, followed by contrast injection (contrast dose of 0.15 mmol/kg, Multihance(Bracco Diagnostic Inc., Princeton, NJ)). Serial 3D T1-weighted imaging of the whole heart was performed to identify the regions of the myocardium ablated in the EP-suite (Figure 1 shows a representative image of the LV of one animal at different times after contrast injection). The parameters for the scan were as follows: respiratory navigated, ECG gated, saturation recovery prepared GRE sequence with resolution=1.25x1.25x2.5 mm, TR/TE=2.9/1.4 ms, flip angle=12°; TI=200ms, parallel imaging with R=2. The lesions were segmented into 2 regions – the lesion core determined by the no-reflow region identified from the earliest T1-w image, the surrounding edema region determined by the bright regions right around the lesion from the second T1-w scan. A region of normal myocardium was chosen away from the lesion and a blood pool region was also identified.

The mean signal intensities and the standard deviations of lesion core, edema, and normal myocardium and blood pool were measured from the segmented images over different times post contrast injection to study the contrast kinetics of the various tissues after ablation (Figure 2a). The contrast to noise ratio (CNR) between edema and normal myocardium (CNR_{en}) and edema and blood pool (CNR_{eb}) were also evaluated as the difference between the signal intensities normalized by the mean standard deviation of the normal myocardium (Figure 2b).

Figure 1(a – e). Representative T1w image of lesion and edema acquired at various times after contrast injection. Green arrow shows edema, red arrow - lesion core.
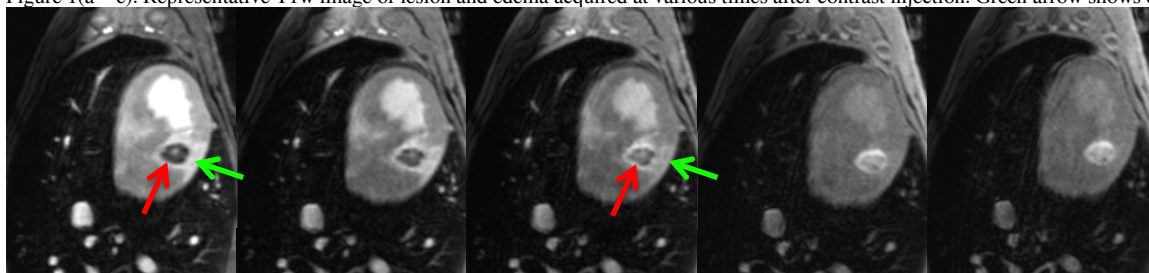
a. 3 minutes post
b. 6 minutes post
c. 10 minutes post
d. 25 minutes post
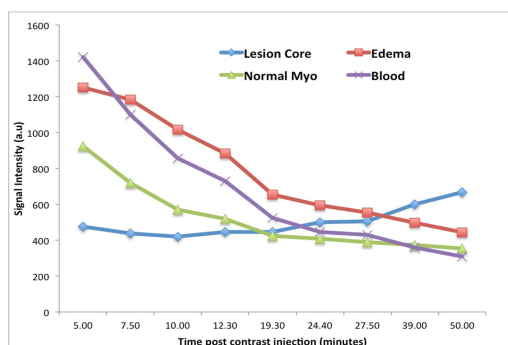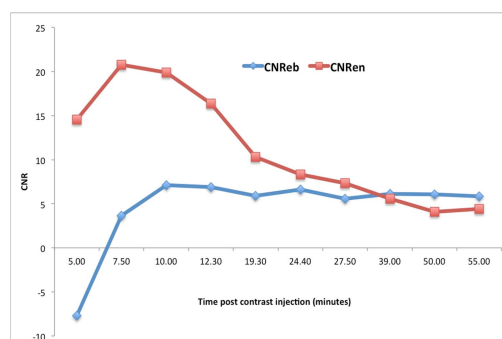e. 30 minutes post
contrast injection

Figure 2a. (left) Dependence of image intensity of tissues on time after contrast injection.

Figure 2b. (right) Dependence of CNR between region of edema and blood and CNR between region of edema and normal myocardium on time afer contrast injection.

Results

It can be seen in Figure 1 that various post ablation tissues (lesion and edema) appear different at different times post contrast injection. Figure 2a clearly shows that lesion core takes at least 45 minutes to enhance while edema on the other hand enhances immediately after contrast (similar to blood). This property may be used to clearly differentiate between edema and lesion core. From Figure 2b, it can be understood that edema loses contrast soon as well and by the time lesion is enhanced, there is no visible contrast left to differentiate between edema and normal myocardium. The best time to visualize edema with good contrast is < 10 minutes after contrast injection.

Conclusion/Discussion

In conclusion, this work shows that lesion core, edema and normal myocardium may be differentiated post ablation early after contrast injection when edema is brightest. The lesion core may be identified by dark regions of no-reflow early after contrast injection or by enhancement very late after contrast injection.

References

1. Haissaguere M et al. *N Engl J Med* 1998; 339:659-66. 2. Cappato R et al. *Circ*. 2005; 111:1100-5. 3. Kholmovski E et al. *ISMRM* 2011

Acknowledgements