

# Simultaneous three-dimensional visualisation of delayed enhancement and T<sub>2</sub> weighted MRI for the characterisation of RF ablation lesions.

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## Introduction

Radiofrequency (RF) ablation is a common treatment for atrial fibrillation (AF). In this catheter-based intervention, the pulmonary veins (PVs) are electrically isolated by ablating the atrial wall around each PV ostia [1] to cause cell death and thus forming conduction blocks. The endpoint of the procedure is usually determined by measuring signals within each PV to ensure electrical isolation. Recently, delayed contrast enhanced MRI has been proposed to visualize necrotic tissue after RF-ablation [2]. This imaging technique may be used in addition to electrical measurements to monitor success of ablation procedures based on cell death. Cell death however, is not the only process causing electrical isolation. A second consequence of RF ablation is the formation of oedema, which has also been suggested to cause conduction block [3]. Oedema presence is temporary, and once subsided electrical isolation of the PVs may be lost, causing a reoccurrence of AF. In this study we use a combination of delayed contrast enhanced and T<sub>2</sub> weighted (T<sub>2</sub>W) MRI on patients with acute ablation lesions to determine areas of true electrical block as well as areas of oedema.

## Methods

### MRI Protocol:

Five patients diagnosed with AF underwent a catheter intervention in either the XMR suite (n=3), or in a catheter laboratory (n=2) MRI procedures were performed pre and post intervention. All scans were performed on a 1.5T Philips Achieva scanner (Philips Medical Systems, The

Netherlands) using either a 32 channel surface coil, or if the intervention was performed in the XMR setting, a large 2 element flex coil. Each MR protocol consisted of a T<sub>2</sub>-prepared balanced turbo field echo (b-TFE) for registration purposes; a double inversion recovery (DIR) multi slice turbo spin echo (TSE) for black-blood oedema detection; a contrast enhanced magnetic resonance angiography (MRA) of the left atrium for image segmentation and a delayed enhancement scan approximately 20 minutes after contrast agent administration (0.4ml/kg of 0.5mmol/ml Gd-DTPA) for lesion detection. The post intervention scans were performed approximately 30 minutes after the intervention in the XMR setting, or else one day after intervention performed in the catheter laboratory. The patients underwent the same MRI protocol to detect changes in the baseline T<sub>2</sub>W and delayed enhancement scans. The scan parameters for the DIR-TSE were: TE= 120ms, free-breathing, ECG, triggered, linear k-space, 5mm slice thickness, 1.5x1.5mm<sup>2</sup> resolution. The scan parameters for the IR-TFE scan were: 3D IR-TFE, 150ms acquisition window, free-breathing, ECG triggered, low-high k-space ordering, TR/TE/α = 6.2ms/3.0ms/30°.

### 3D surface creation:

A surface of the left atrium was derived by automatically segmenting the MRA. This surface was fused with the post-intervention DIR-TSE and IR-TFE images by following a transformation using a combination of DICOM geometry information and 3D rigid mutual image information (MI) registration techniques. Once fused, a maximum intensity projection (MIP) was performed into both images at ±3mm along the normal vector to each surface vertex. Each vertex was assigned that MIP value. Areas of a high MIP value were defined by thresholding any MIP value greater than an area of signal intensity from the healthy myocardium plus three standard deviations. Defined areas from both the DIR-TSE and IR-TFE intensity-mapped surfaces were overlaid onto the left atrial surface.

## Results

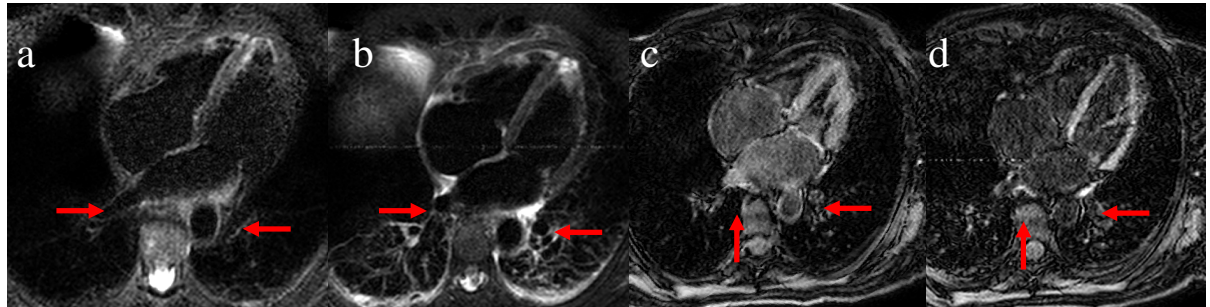
Pre- and post-intervention MRI can be observed in Fig 1. Areas of high signal intensity can be observed around the regions of the PVs. On 3D inspection (Fig. 2), gaps in the pattern of delayed enhancement were observed, suggesting that anatomical isolation of all the PVs was not achieved. It was determined that in these cases, any gaps in the delayed enhancement were completed with areas of oedema, providing temporary electrical conduction.

## Discussion and Conclusions

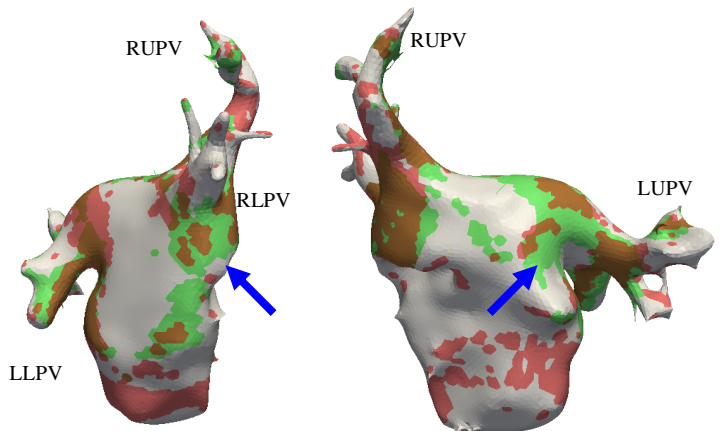
To date, all patients remain free from AF, however the ablation lesions may still be considered acute, and oedema may not have subsided. We intend to have all patients return for a follow-up MR scan to visualise the chronic ablation lesions; to assess any changes in the extent of oedema and necrosis and correlate with patient outcome at a later stage. Imaging of ablation lesions using both oedema and scar imaging in the acute setting may provide a better assessment of RF ablation lesions than imaging with late enhancement MRI alone.

## References

[1] Pappone *et al.* Circulation 2000;102:2619-2628. [2] Peters DC *et al.* Radiology 2007;243:690-695. [3] Yamada T. *et al.* Europace 2006;8:182-188.



**Fig 1:** Pre- and post-intervention MRI images of the left atrium in the four chamber view. (a) and (b) are the pre- and post-T<sub>2</sub>W images, respectively. (c) and (d) are the pre- and post-delayed enhancement images. On the post-intervention images, changes in signal intensity (red arrows) can be observed, indicating the presence of oedema and ablation lesions in the regions of the PVs.



**Fig 2:** 3D visualisation of the patterns of delayed enhancement (red), oedema (green) or both (brown). Electrical isolation was achieved, but the blue arrows indicate areas where only oedema is present. These areas may become healthy tissue and thus the patient may have a reoccurrence of AF.