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Late gadolinium enhanced MRI in small animal models of myocardial infarction

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Introduction

Late gadolinium enhancement (LGE) is widely used to assess myocardial infarction (MI) in patients using inversion recovery (IR) sequences, which provide optimal contrast between infarcted and healthy myocardium. However, studies involving small animal models of MI generally use short-TR T1-weighted imaging, with few exceptions [1-4], mainly due to rapid heart and respiratory rates and long T1 times at high field.

Purpose

This study presents a new protocol to assess infarct size in both a reperfused rat MI model and a permanent occlusion mouse model at 9.4 T. We utilised a combination of Look-Locker to evaluate optimum TI and a multi-slice IR sequence to yield high SNR and contrast images for accurate assessment of infarct area.

Methods

Wistar rats (n = 7) underwent 30 minutes of myocardial ischaemia by ligation of the LAD. B6Sv129 mice (n = 6) underwent permanent occlusion.

Imaging was performed on a 9.4 T Varian (VNMRS) system using 72 mm transmit coil with a four-element receive array for rats, and a 33 mm volume coil for mice. 0.6 mmol/kg Gd-DTPA was administered intravenously in rats, and intraperitoneally in mice.

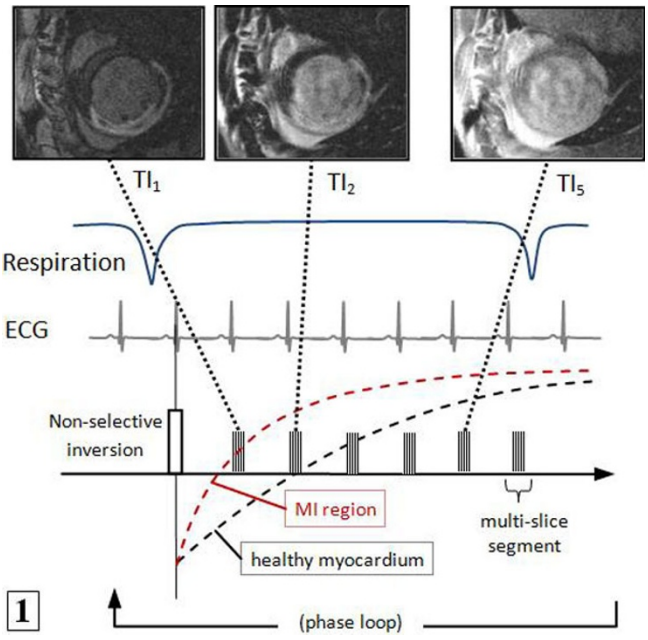

Figure 1
The pulse sequence and gating strategy used to acquire multiple TI images following adiabatic inversion. Images from $TI_{1, 2, 5}$ time point are shown above, where the indices relate to number of ECG triggers since inversion. Acquisition parameters were; 0.2 × 0.2 × 1 mm resolution, TE = 1.3 ms, TR = ~1 s, FA = 10°, NSA = 1, TA ~3 minutes.

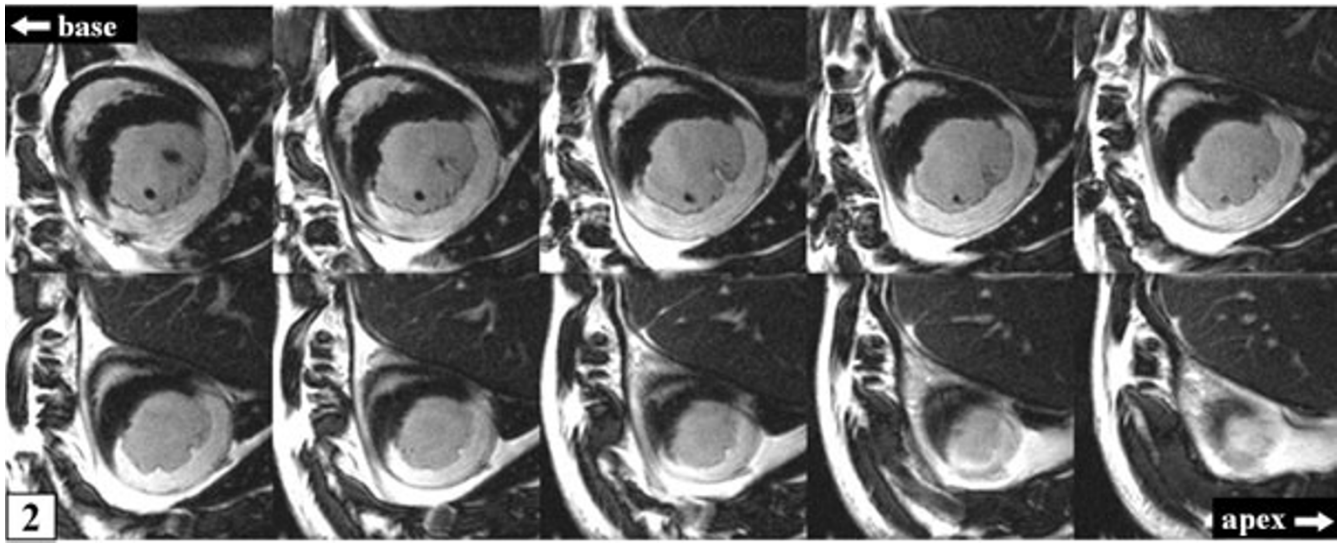

Figure 2
Representative images of late gadolinium enhancement in an acute reperfused rat MI model using the inversion recovery sequence described. Ten contiguous slices are shown here, from just above mid-ventricle down through to apex, highlighting the infracted region.

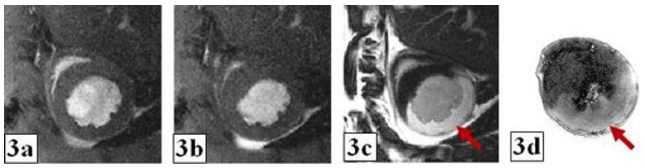

Figure 3
Shows end-diastolic (a), end-systolic (b) frames from cine data alongside IR-LGE image (c) and corresponding TTC histology section (d), revealing a large region of infarction in rat 2 hrs post MI (red arrows).

Cine cardiac data was acquired using a GRE sequence (TE/TR = 1.3/4-8 ms, 20 frames, 0.2 × 0.2 × 1 mm resolution, NSA = 1) in order to assess contractile dysfunction. Following Gd-DTPA a Look-Locker sequence was used to acquire multiple-TI images as illustrated in Figure 1. This was followed by a multi-slice IR acquisition with FA = 90° and TI selected to achieve maximum contrast.

Results

Figure 2 shows typical LGE images from a rat 2 hours following MI, acquired ~10 minutes post Gd-DTPA.

Figures 3a-d show validation of LGE image with cine data and TTC staining.

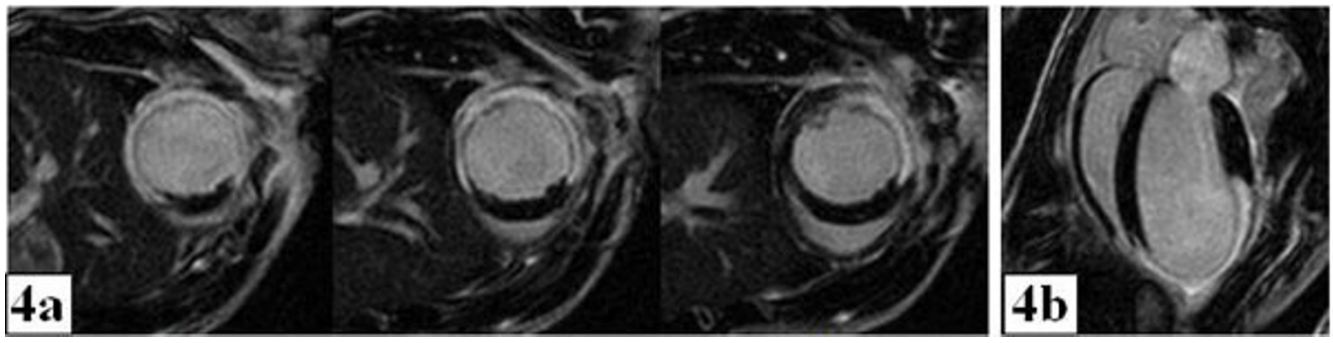

Figure 4
Example of late gadolinium enhanced images of a mouse 48 hrs after MI showing 3 consecutive short-axis slices (a), and a 4-chamber long-axis view (acquired separately) revealing the extent of the infracted region.

Table 1: SNR and CNR measurements from rat data

Signal-to-noise ratio	
Infarcted myocardium	54.2 ± 10.4
Healthy myocardium	4.6 ± 0.5
Blood pool	31.7 ± 6.3
Relative contrast (%)	
Infarct to healthy myocardium	1101.3 ± 169.9
Infarct to blood	71.6 ± 18.6
Contrast-to-noise ratio	
Infarct to healthy myocardium	49.6 ± 10.1
Infarct to blood	22.5 ± 4.6

Figure 4 shows representative LGE images of mice 2 days following permanent occlusion. In addition to the short-axis stack a 4-chamber view is often useful to aid segmentation.

Table 1 lists SNR and CNR measurements from rat LGE data (n = 7).

Conclusion

IR sequences provide optimum contrast in LGE imaging, allowing accurate delineation of infarct area. Here we demonstrate that they can readily be applied to small animal models of MI. We have established a protocol that uses a Look-Locker method for optimising TI and a multi-slice IR sequence for high SNR and contrast. With acquisition times of < 10 minutes this protocol allows for accurate and fast MRI screening in small animal models.

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