Dual inversion recovery pre-pulse differentiates contrast uptake from oedema in late gadolinium enhancement imaging of the atrial wall after radiofrequency ablation

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Introduction: Pulmonary vein isolation using radiofrequency (RF) ablation is an established treatment for patients with atrial fibrillation (AF). Late gadolinium enhancement (LGE) imaging using the inversion recovery (IR) pre-pulse can be performed acutely after ablation. However the IR sequence only nulls the signal from the normal atrial wall and therefore generates high signal from areas of oedema as well as contrast uptake. In this study, we aimed to assess whether the dual-IR pre-pulse can help differentiate contrast uptake from oedema in LGE imaging to help visualize acute damage caused by RF ablation.

Methods:

LGE Pulse Sequences: The conventional IR-GE pre-pulse (fig. 1a.) consists of a non-selective inversion pulse followed by an inversion delay (TI) which is set to suppress normal atrial wall using a preceding Look Locker scan. The dual-IR-GE sequence (fig. 1b.) employs two non-selective inversion pre-pulses separated by two time delays, TI1 and TI2. These delays were optimized to achieve signal suppression of all T1 species greater than 250ms according to the patient's heart-rate (1).

Patient scan: Approximately 24 hours after RF ablation for AF, a 50-year-old female patient underwent MR imaging using a 32 channel coil at 1.5T Philips Achieva scanner (Philips Healthcare, Best NL). After initial localizer scans, T2-weighted black-blood TSE imaging was performed for the visualization of oedema. Imaging parameters included: TE/TR = 120/1410ms, flip angle = 90°, voxel size = 1.0x1.0x5mm and 3 signal averages. 0.2mmol/kg of gadopentate dimeglumine (Magnevist, Bayer Schering AG, Berlin) was then administered. Conventional IR-GE imaging was performed after 25 minutes, followed by dual-IR GE imaging at 30 minutes. Both IR and dual-IR pre-pulses were combined with a 3D free breathing, respiratory-navigated, ECG-triggered gradient echo (GE) read-out (2). Imaging parameters included: TE/TR = 2.6/5.4ms, navigator window = 5-7mm, flip angle = 25°, voxel size = 1.2x1.2x4mm (reconstructed = 0.6x0.6x2mm). A delay of 100ms was applied between the navigator and image acquisition to avoid the pulmonary vein inflow artifact (3). In all sequences, image acquisition was timed at end diastole using a preceding balanced steady state free precession (bSSFP) cine image.

Results:

Signal versus T1 plots for the IR-GE sequence (fig. 1c.) show that the signal in the normal atrial wall is suppressed and there is high signal in areas of contrast uptake. However there is also high signal for all other T1 species including blood and fluid However due to the exact timing of the two inversion pulses, the dual-IR sequence suppresses signal for a wide range of T1 values (fig.1d.). This means it achieves suppression of normal atrial wall and fluid while maintaining high signal in areas of contrast uptake. The blood signal is also reduced compared to the IR sequence. In T2-weighted images (fig. 2a.) there is high signal in the pleural effusion and pericardial oedema. In the conventional IR-GE images, there is high signal in the atrial wall relating to contrast uptake as a result of tissue damage caused by the RF ablation. This is obscured somewhat by the bright signal in the area of oedema. The pleural effusion is also bright in these images. In the dual-IR images, the signal in the pleural effusion is completed suppressed as is the signal in the pericardial oedema. This makes it easier to depict the areas of contrast uptake in the atrial wall.

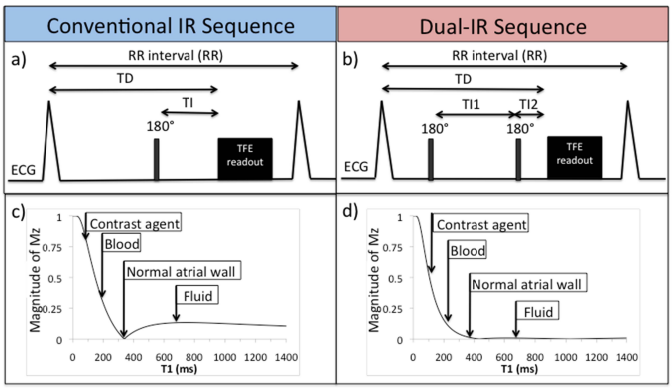

Fig. 1: Pulse sequence designs for the IR (a) and dual-IR (b) pre-pulses. |Mz| vs T1 plots show that the IR only suppresses the signal of normal atrial wall (c) whereas the dual-IR suppresses atrial wall, blood and fluid (d). The post contrast T1 of fluid was estimated as 640ms from the Look Locker scan.

Conclusion: The dual-IR pre-pulse only generates high signal from areas of contrast uptake. The signal from fluid and normal atrial wall are suppressed improving the specificity of the scan for visualizing contrast agent.

References: 1) Peel SA et al. Proc. ISMRM 2011 E-poster 3387, 2) Peters DC et al, JACC 2:308-16 (2009), 3) Moghari MH et al. MRM 66:180-186 (2011).

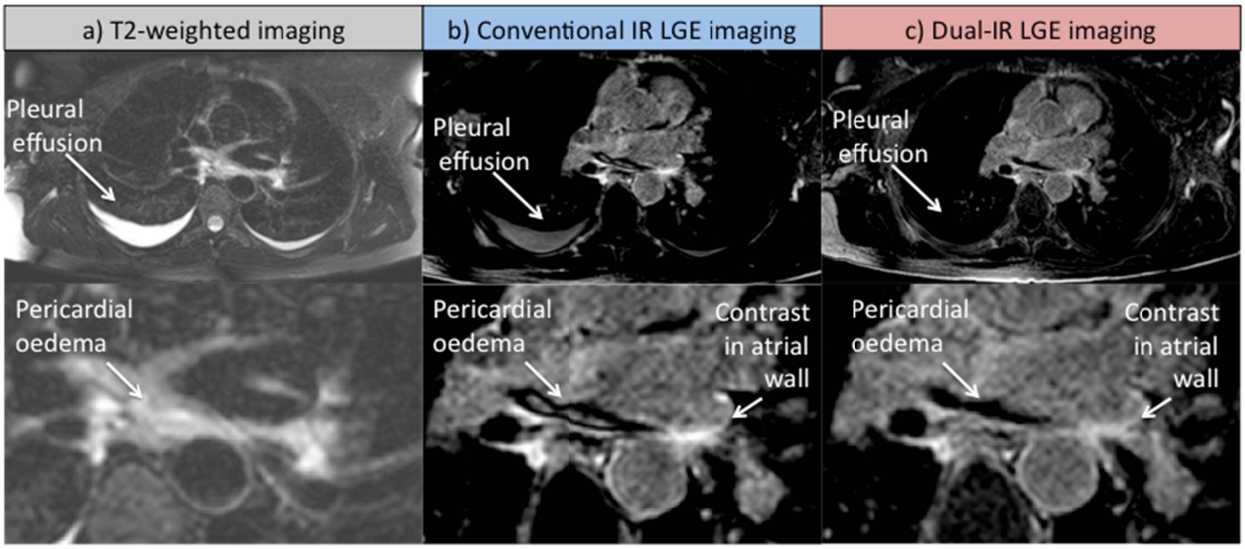

Fig. 2: T2-weighted oedema imaging (a) showing bright signal in the pleural effusion and pericardial oedema, conventional IR-GE LGE imaging (b) showing high signal in the pleural effusion, pericardial oedema and contrast in the atrial wall and dual-IR LGE imaging (c) which suppresses the signal in the pleural effusion and pericardial oedema but maintains high signal in the atrial wall.