Improved Myocardial Viability Imaging with T2-Prepared Inversion Recovery (T2PREP-IR)

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Introduction The most common MR approach for evaluating the viability of myocardium in ischemic heart disease is the use of an inversion-recovery (IR) fast gradient echo (GRE) sequence several minutes after the administration of a gadolinium (Gd) based contrast agent[1]. The optimal inversion time (TI) is selected to suppress signal from normal myocardium, providing high conspicuity of the enhancing myocardial infarction (MI). Such delayed-enhancement (DE) imaging exhibits excellent contrast between infarcted and normal myocardium. However, the blood in the cardiac chambers and the MI have similar T_1 values, potentially resulting in a lack of contrast between the ventricular blood and subendocardial infarction that can limit the detection and evaluation of infarcted tissue. Therefore, differences in the T_2 of blood and myocardium can be exploited to produce contrast between these tissues. Kellman *et al* proposed a technique that acquires an additional image with T_2 weighting that is perfectly registered to the DE image[2]. We propose a method that combines IR and T_2 preparation into a single magnetization-prepared sequence (T_2Prep-IR[3]) to acquire a single image with mixed T_1 and T_2 contrast, thereby improving the contrast between enhancing subendocardial infarction and intrachamber blood.

Theory

The T_2Prep-IR pulse sequence consists of a T_2 preparation[4] followed immediately by a nonselective adiabatic inversion pulse. The first imaging excitation is then delayed an interval TI to allow nulling of a particular T_1 species (eg. normal myocardium in a viability study). The amount of T_2-contrast is determined by the T_2Prep duration, TE_{eff}. TE_{eff} is selected to differentiate species that share similar T_1 values but have different T_2 values (eg. MI and blood). The contour plots in Fig.1 summarize the contrast between normal myocardium (T_1/T_2=390/50ms), chamber blood with Gd (T_1/T_2=250/250ms), and myocardial infarction (T_1/T_2=250/50ms[2]) 15 minutes after contrast administration. The T_1 of MI was chosen to represent the worst case encountered in DE studies, when the T_1 of blood and infarcted myocardium are identical. By adjusting TE_{eff} and TI values, different contrast can be attained. No signal difference is seen between MI and blood when TE_{eff} is close to zero. By increasing the TE_{eff}, contrast between enhancing myocardium and blood can be generated, due to differences in T_2 between these tissues. However, Fig.1 also indicates that the optimal TI to null myocardium is decreased when TE_{eff} is increased and myocardiaum and MI are not differentiable when TE_{eff} is greater than 50ms due to signal decay from their short T_2 values. Hence, a short TE_{eff} is preferred and may be sufficient to achieve good contrast between infarcted myocardium and chamber blood.

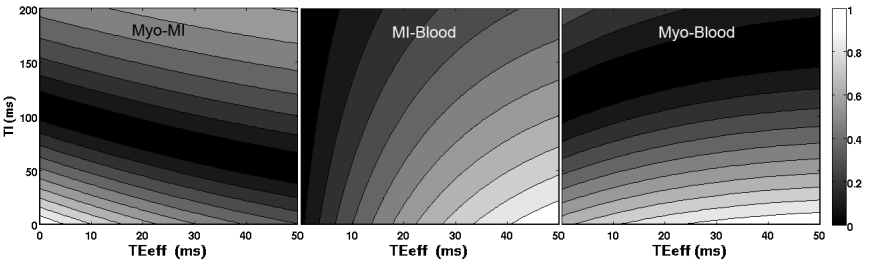

Fig. 1 T_2Prep-IR magnetization-prepared contrast between myocardium (Myo), blood, and infarcted tissues (MI) in the DE process.

Methods The T_2Prep-IR preparation was incorporated into a fast GRE sequence that is used clinically for viability studies at our institution. Imaging on volunteers and patients was performed on clinical 1.5T GE Signa HDx scanners using an eight-channel phased array coil, with approval from our IRB and after obtaining informed consent. T_2Prep-IR images were acquired subsequent to the standard IR imaging at the same slice locations. Images were obtained 10-20 minutes after IV administration of 0.15mmol/kg of gadobenate dimeglumine (Multihance, Bracco, Princeton New Jersey) using the following protocol: ECG-gated, TR/TE=6.4/3.1ms, flip angle=20°, 32 k_y lines acquired every other heart beat, slice thickness/FOV=8/350mm, 256x192 matrix.

Results: Fig.2 shows representative short-axis images acquired in a healthy volunteer. Image contrast was varied by adjusting TE_{eff} and TI. The optimal TI to null myocardium is decreased when TE_{eff} is increased, as predicted. Blood signal is also reduced with increasing TE_{eff}, which should aid in differentiating subendocardial MI (not present in this healthy volunteer) from blood pool. DE cardiac MRI techniques have also been used for the assessment of pericardial inflammation[5]. Fig. 3 demonstrates four-chamber views acquired in a patient with pericarditis. Note the improved differentiation between the inflammatory pericarditis (arrows) and the myocardium using T2Prep-IR compared to the conventional IR approach.

Discussions: We have demonstrated that a T_2Prep-IR preparation generates images with mixed T_1 and T_2 contrast. Simulations predict that this method will generate improved contrast between MI, chamber blood, and normal myocardium compared to conventional IR methods of delayed-enhancement imaging. Initial results are demonstrated for a patient with pericarditis. An investigation in patients with MI is commencing soon.

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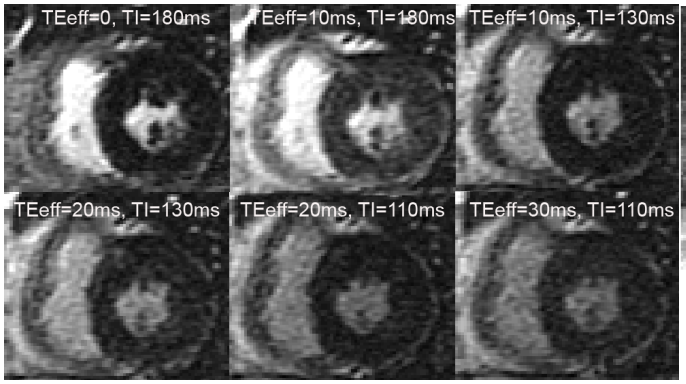

Fig. 2 Short-axis images of a normal volunteer illustrating the effectiveness of T_2Prep-IR. The optimal TI to null normal myocardium decreases when TE_{eff} is increased. Blood signal is reduced with the increasing of TE_{eff}, which should aid in differentiating subendocardial MI (not present in this healthy volunteer) from blood pool.

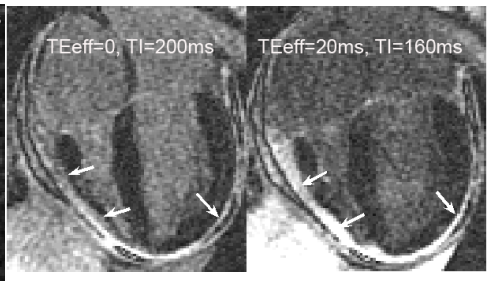

Fig. 3 Inflammatory pericarditis in a patient presenting with IR (left) and T_2Prep-IR (right) preparations. Thickened pericardium (arrows) is well seen with T_2Prep-IR.

Ref [1] Simonetti OP, et al. Radiology.2001;218(1):215-23. [2] Kellman P, et al. JMRI. 2005;22:605-613.[3] Brittain J, et al. MRM. 1997;38(3):343-354. [4] Brittain J, et al. MRM. 1995;33(5):689-96. [5] Taylor AM, et al. Eur Radiol. 2006;16:569-574.