A FAST, TI INSENSITIVE INFARCT IMAGING TECHNIQUE

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Introduction
Following myocardial infarction, the extent of irreversible myocardial injury has important prognostic implications. In MRI, the delayed enhancement technique can distinguish between viable and non-viable myocardium [1]. Segmented inversion recovery turbo FLASH (IR-TFL) has been shown to give the best contrast between viable and infarcted myocardium [2]. However, the segmentation technique requires breathholding and a regular RR interval for good image quality. Single shot inversion recovery trueFISP (IR-trueFISP) gives good image quality independent of heart rate variation [3] but complete nulling of normal myocardium is difficult due to the long acquisition window, resulting in reduced contrast between normal and infarcted myocardium. The TI scouting method [4] requires multiple heart beats. A MR infarct imaging technique insensitive to both TI and RR interval is highly desirable for arrhythmic patients.

Purpose
To design an arrhythmia and TI insensitive sequence on a clinical MRI scanner equipped with high performance, state of the art gradient systems and apply it to infarct imaging.

Methods
The sequence
The acquisition of the IR-prep image was based on the single shot 2D IR-trueFISP sequence [3]. Phase sensitive reconstruction (PSRecon) as proposed in [5] was used to make the method insensitive to TI by eliminating the need for precise nulling of normal myocardium. Phase information needed in PSRecon was obtained from a reference image acquired in the second (or later) heart beat, performed with identical gradient structures as the IR-prep image except that a low flip angle (8^o in this case) was used. The low flip angle acquisition gives a reference image that is nearly proton density weighted. In both acquisitions, the linear flip angle method was used for steady state preparation before echo collection. Asymmetric echoes are used to shorten TR and hence enable the collection of more lines per shot. Fig.1 shows the sequence timing.

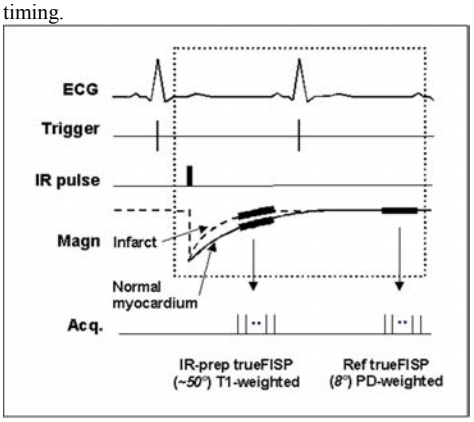

Fig.1 The phase sensitive reconstruction IR-trueFISP sequence

Both IR-trueFISP and IR-TFL were implemented on a MAGNETOM Sonata (Siemens, Erlangen, Germany, max. gradient = 40mT/m, max. slew rate = 200mT/m/ms). Image reconstruction was performed online.
Patient imaging
5 patients with known infarcts were imaged using the two sequences described above. All patients gave written informed consent. The protocol was approved by the IRB of Northwestern University. After initial scout images were obtained, cine images were acquired for multiple short axis (8-10 slices) and two long axis (2-chamber and 4-chamber) views to evaluate contractile function. Gadoteridol (0.1mmol/kg of Prohance from Bracco) was then administered intravenously. Images were acquired for identical views ~10 min after contrast injection using the IR-TFL sequence. PSRecon IR-trueFISP was then used to image the slices where infarcts were present. Parameters used in the sequences were:

IR-TFL: ECG trig, 124 lines, 25 segments, FOV = ~270mm x 360mm, slice = 6mm, flip angle = 30^o, TE/TR = 4.3ms/11ms, TI = 300 – 400ms, bandwidth/pixel = 140Hz, gradient refocused, image matrix = 256^2. Lines acquired every other beat. Scan time = 10 beats.
PSRecon IR-TrueFISP: ECG trig, ~100 lines, single shot, FOV = ~270mm x 360mm, slice = 6 – 8mm, flip angle = 30^o-50^o. TE/TR = 1.2ms./2.7ms, TI = ~300ms, bandwidth/pixel = 980Hz – 1200Hz depending on heart rate, image matrix = 256^2.
Nonselective IR pulses were used in both cases to avoid flow artifact. Acquisitions were timed to occur at the diastole and the window was kept to about 275ms.

Results
Infarcts in all 5 patients showed up very well in images acquired using the sequence in Fig.1. Fig.2 shows a set of typical images from this technique obtained from a patient with acute MI. The conventional IR-TFL image, obtained with careful choice of TI to null normal myocardium, showed the infarct and the no-reflow region (Fig 2a). Fig 2b was obtained from the single shot IR-trueFISP with an TI shorter than it should be for nulling of normal myocardium. Note the reduced contrast and signal variability in the normal myocardium. Fig 2c shows the PSRecon of the same data set with the help of the reference image (Fig 2d) using the new technique. The infarcts and the no-reflow zone were shown with uniform nulling of viable myocardium.

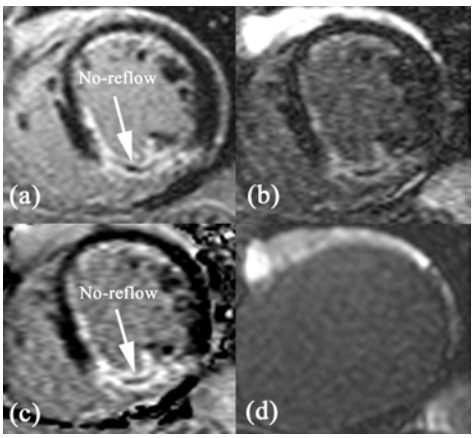

Fig.2 Images from the conventional IR-TFL (a), the magnitude reconstructed IR-trueFISP (with TI=300ms) (b) - note the reduced contrast between infarct and normal myocardium, as well as the hyperenhancement, the corresponding PSRecon IR-trueFISP (c) obtained using the coil sensitivity map (d) collected from the low flip angle trueFISP acquisition.

Conclusion
The PSRecon IR-trueFISP acquired images comparable in quality to IR-TFL without the requirement of precise TI selection for myocardial nulling or uniform R-R intervals over multiple heart beats. The short acquisition time makes this sequence less susceptible to variations in R-R interval (e.g., PVC's) than the standard segmented technique. Additionally since the scan time of the technique is so short and the TI does not need to be changed from one scan to the other, repeated acquisitions can be performed quickly and easily. These properties of PSRecon IR-trueFISP may make it useful in the screening of patients for myocardial infaction.

References
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