Improved turbo spin-echo imaging of the heart with motion-tracking

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• Introduction
Turbo spin-echo (TSE) imaging is used extensively in cardiovascular magnetic resonance to depict cardiac morphology. Dark-blood preparation is implemented routinely to remove signal from blood and, if necessary, STIR (short tau inversion recovery) preparation is implemented to remove signal from fat. The efficacy of the technique depends upon the plane of interest being in the same spatial position during the TSE acquisition (in diastole) as it is during the dark-blood and STIR preparations (600ms and 170ms earlier respectively). This is a particular problem when imaging the basal short axis ventricular plane where through-plane motion is high, and poor quality images are frequently obtained. In order to improve this, we have developed a motion-tracked TSE sequence in which the slice-selective dark-blood and STIR preparations are individually positioned so as to track the motion of the imaged plane.

• Methods
Ten healthy subjects were studied on a Siemens Sonata 1.5Tesla scanner. In each subject, the motion of the basal ventricular short axis plane was determined using a cine imaging sequence with a labelling pre-pulse. Interleaved horizontal (hla) and vertical (vla) long axis acquisitions were acquired in a single breath-hold with the labelling being performed perpendicular to both planes, just below the level of the valves. The resulting images show the motion of the labelled basal short axis slice throughout the cardiac cycle in both vla and hla planes. A TSE sequence was modified to allow independent positioning of the slice-selective dark-blood and STIR preparations on the appropriately timed labelled images. The dark-blood inversion time was calculated to give optimal blood signal suppression and is heart rate dependent (typically 600ms). The STIR preparation was output 170ms before the TSE imaging segment to give optimal fat suppression. The resulting images were scored on a scale of 1 (very poor) to 5 (excellent) by two independent observers and compared with those obtained with the standard untracked imaging sequence using a paired Wilcoxon analysis.

• Results
The labelled images show that the maximal motion of the anterior, inferior, lateral and septal walls of the left ventricular basal short axis plane are 10.0 +/- 2.2mm, 14.7 +/- 2.6mm, 14.0 +/- 1.9mm and 11.8 +/- 1.8mm respectively. The right ventricular basal plane is more mobile than the left with anterior, inferior and lateral maximal motion of 17.0 +/- 2.6mm (p < .001), 20.9 +/- 3.2mm (p < .001) and 20.9 +/- 2.7mm (p < .001). Figure 1 shows the positioning of the dark-blood and STIR preparations ((a) and (b) respectively) and of the TSE imaging (c) for a basal short axis plane. Example images both without (a) and with (b) motion tracking of the left ventricle are shown in Figure 2. The image quality of the tracked image is clearly superior to that of the untracked image where motion between the preparation and imaging phases has resulted in considerable and patchy signal loss. A second example is shown in Figure 3 where this time, the motion of the right ventricle has been tracked again resulting in substantial improvement. Of note, however, is that since the STIR preparation is now no longer output in the same plane as the TSE imaging, the fat suppression is not uniform but should be optimal for those regions moving with the ventricle being tracked. For the normal subjects as a whole, for the basal plane of both left and right ventricles, tracked images were superior to the untracked images (4.9 +/- 0.3 vs 3.3 +/- 1.1, p < .01 and 3.9 +/- 1.0 vs 1.8 +/- 0.6, p < .01 respectively).

• Conclusions
Tracking the through-plane motion of the heart between preparation and imaging phases improves the quality of TSE images, particularly in the basal short axis plane and particularly for the more mobile right ventricle.