Myocardial Perfusion by Single-Shot TrueFISP Arterial Spin Labeling

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INTRODUCTION

MRI Arterial Spin Labeling (ASL) technique can be used to measure perfusion noninvasively by taking advantage of the endogenous contrast from flowing blood itself. Most ASL techniques use echo planar imaging (EPI) or STAR-HASTE techniques. However, susceptibility artifact associated with EPI and blurring artifact in the phase encoding direction of the single shot STAR images, as well as the poor signal to noise ratio (SNR) have limited the application of ASL. Furthermore, while the ASL technique has been applied in functional brain imaging, only a few preliminary studies have been published on myocardial perfusion, due to challenges of cardiac and respiratory motion. We used a single shot TrueFISP technique to address motion and SNR issues and evaluated it in subjects with normal or abnormal myocardial perfusion patterns. To avoid the complex issue of tagging pulse placement relative to coronary artery anatomy and flow, a flow sensitive alternating inversion recovery (FAIR) technique was employed to collect paired images with non-selective and selective IR pulses at the same location.

MATERIAL AND METHODS

Eleven Volunteers (ages: 25 to 73, 5 females) without documented coronary artery disease signed informed consents and were enrolled after the hospital IRB approval. The study was performed on a 1.5 T Siemens Sonata scanner (Siemens Medical Solutions, Malvern, PA) with a CP body array flex coil. The ASL images were collected at a mid ventricular short axis slice with breath holding, alternating selective and non-selective IR pulses. Assuming myocardial and blood T1 are similar, the signal difference between two FAIR images is proportional to the myocardial flow. Optimal TI for maximal flow should be close to blood T1, 1200ms. However, in order to ensure the inversion pulse excites the myocardium imaged, we use the RR interval of the subject as the TI and select a trigger delay so that the data acquisition falls within the early diastole. To increase the SNR, the data acquisition was averaged four times. The imaging parameters for IR TrueFISP were as following: TR/TE/FA = 2.9ms/1.3ms/65°, data matrix 90×192, rectangular field of view (FOV) 25×34cm^2, bandwidth (BW) per pixel 980Hz and voxel spatial resolution 3.5×1.9×10 mm^3 dependent on the size of the subject. The acquisition time per image was about 160 ms. The profile width of the slice select inversion pulse was about 3 times the real data excitation slice to avoid motion and impurity of inversion pulse profile.

To induce a flow change, adenosine stress was used on one normal volunteer. The technique was also tested on a patient with an 18-year-old infarct and correlated with a standard delayed hyperenhancement region. Siemens Argus software was used for image subtraction and data analysis. ROIs were drawn in the septum, lateral, anterior and inferior wall on the difference images.

RESULTS

ASL perfusion images from all volunteers demonstrate reasonable image quality and uniform signal on myocardium. The signal amplitudes from 10 volunteers showed a large variation among subjects, but were more consistent across different normal myocardial regions in a single individual as shown in **Figure 1**. **Figure 2** showed FAIR images from a post MI patient. (a) is the single shot TrueFISP image with selective IR pulse; while (b) is with non-selective IR pulse; (c) is the difference image. The arrow points to the inferior wall infarct region, extended to septum and lateral sup-endo-myocardial wall. The flow defect region correlates well with the delayed hyperenhancement area in (d).

The average signal among ROIs in all myocardial areas from the adenosine stress volunteers was 221 ± 90.9 at stress, versus 49.6 ± 19.3 at rest, for a ratio of 4.56, consistent with the expected range of normal perfusion reserve.

CONCLUSION

ASL with the breath-hold TrueFISP single shot FAIR technique may have the ability to assess perfusion reserve and detect regional myocardial perfusion defects in man without a contrast agent. The method provides good contrast in myocardium and is easy to implement. Extensive further validation studies are required.

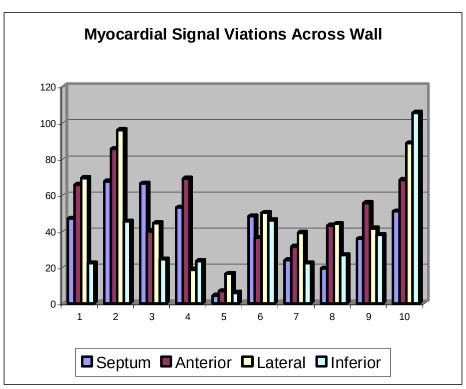
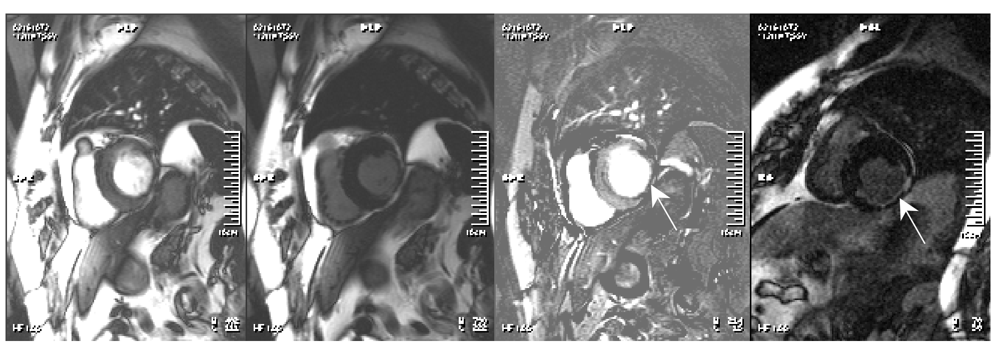


Figure 1. ASL signal variation on different myocardial regions in volunteers study.



a b c d

Figure 2. Example images of a patient with selective IR pulse (a) and with non-selective pulse (b); (c) shows the difference image (image a – image b). The arrow points to the flow defect at inferior wall correlates well with the infarct region in delayed hyperenhancement image (d).