

Black-blood Steady State Free Precession (SSFP) coronary wall MRI for cardiac allografts: A feasibility study

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Background

Heart transplantation (HTx) is the final live saving resort to treat end-stage heart failure. As a consequence of this treatment, cardiac allograft vasculopathy (CAV) is seriously affecting long-term survival of HTx recipients. HTx recipients require periodic follow up exams to monitor development of CAV. Currently, most clinical examinations allowing for directly detecting coronary wall are either invasive of requiring X-ray exposure. Therefore, MRI has emerged as a promising solution for noninvasively detecting morphological abnormalities of the coronary arteries. However, heart rate is usually very fast in HTx recipients because of the denervation or sub-normal re-innervation of "foreign" hearts. Cardiac motion related to fast heart rate becomes a major threat for coronary wall MRI in HTx patients. Unfortunately, traditional turbo spin echo (TSE) technique for coronary wall imaging is sensitive to cardiac motion. Such a drawback impedes its clinical application on recipients of HTx.

Objective

We assessed the hypothesis that steady-state free precession (SSFP) technique allows for imaging coronary wall under the conditions of fast heart rate in patients of heart transplantation (HTx).

Materials and Methods

With the approval of our institutional review board, 28 HTx patients were scanned with a 1.5T scanner. Cross-sectional black-blood images of the proximal portions of the left main artery, left anterior descending artery and right coronary artery were acquired with both two-dimensional (2D), double inversion recovery (DIR) prepared TSE sequence and 2D DIR SSFP sequence. Image quality (scored 0-3), vessel wall area, thickness, signal-to-noise ratio (SNR, vessel wall) and contrast-to-noise ratio (CNR, wall to lumen) were compared between images acquired with TSE and SSFP.

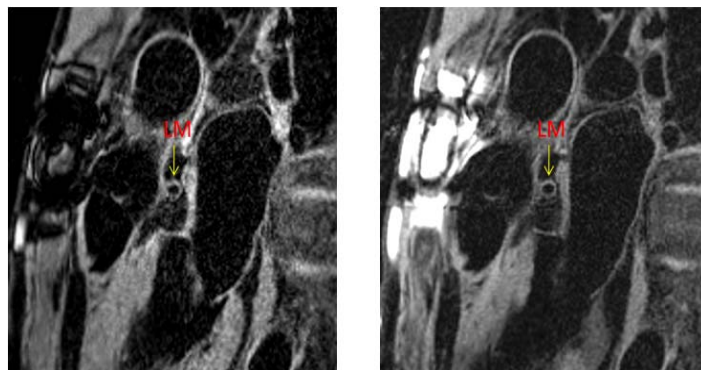


Figure 1 A 55 year-old male, who had a heart transplant 2 years ago. Heart rate: 76 beats per minute. The LM could be clearly seen on both SSFP (Grade 3) and TSE (Grade 3) images.

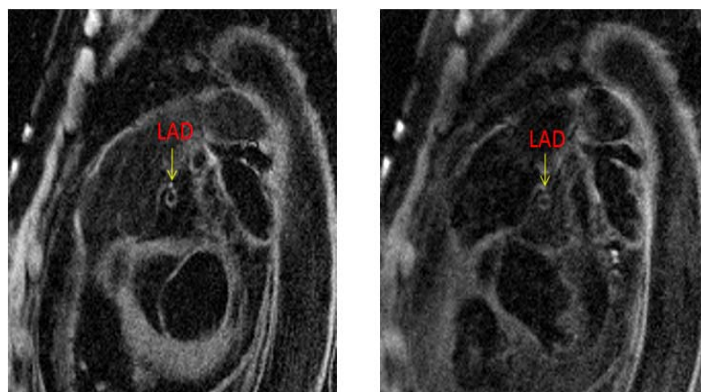


Figure 2 A 73-year-old female, who had a heart transplant 5 years ago. Heart rate: 96 beats per minute. The LAD could be depicted on both SSFP (Grade 3) and TSE (Grade 1). Visually, the image quality of SSFP is better.

Results

The overall image quality of SSFP was higher than TSE (1.23 ± 0.95 vs. 0.88 ± 0.69 , $P < 0.001$). SSFP had a higher coronary wall SNR (20.1 ± 8.5 vs. 14.9 ± 4.8 , $P < 0.001$) and wall-lumen CNR (8.2 ± 4.6 vs. 6.8 ± 3.7 , $P = 0.005$) than TSE. Good agreements of wall area and thickness measurements between SSFP and TSE were observed on matched coronary images with Pearson correlation coefficients of 0.783 and 0.624, respectively ($P < 0.001$). See figure 1-3 for comparisons of image quality between SSFP and TSE under conditions of different heart rates.

Conclusions

Black-blood SSFP coronary wall MRI provides higher image quality, SNR and CNR than traditional TSE does in HTx recipients. SSFP has the potential to become an alternative method for noninvasive imaging of cardiac allografts.

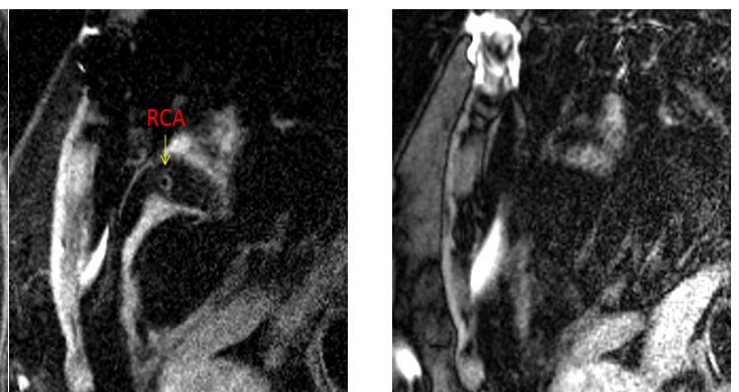


Figure 3 A 61-year-old female, who had a heart transplant 7 years ago. Heart rate: 108 beats per minute. The RCA can only be seen on SSFP (Grade 3), but not on TSE.