Initial Experience with Cardiac Imaging using a Short, Wide Bore 1.5T System

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INTRODUCTION

We present our initial experience with cardiac MR on a short, wide bore system. The wide bore 1.5T MR system provides a new capability for imaging large and claustrophobic patients but also presents unique challenges for cardiac MR due to a reduction in FOV in the z-direction. The image quality, imaging speed, and FOV are characterized for the short, wide bore system as compared to the standard bore 1.5T systems.

METHODS

A cardiac MR protocol consisting of localization (trueFISP), cine function (trueFISP), 1st pass perfusion (GRE-EPI or turboFLASH), and delayed enhancement (turboFLASH) was used to image patients (weighing up to 404 lbs) using the Siemens Magnetom Espree 1.5T system (70 cm bore, 125 mm length, 33 mT/m, SR 100T/m/s) (Fig.1). More than 200 patients have been scanned to date (14 patients > 300 lbs). Parallel imaging (rate=2) was used for localization and cine (GRAPPA), as well as perfusion (TSENSE). Siemens product spine and body array coils (12 elements) were used.

The reduction in imaging speed due to reduced gradient performance of the wide bore system was measured for each protocol and compared with equivalent protocols on the Avanto with higher performance gradients (45 mT/m, SR 200 T/m/s). The z-FOV was measured using the sagittal localizer as the region clear of banding artifacts since the trueFISP sequence is highly sensitive to off-resonance caused by field inhomogeneity. Myocardial SNR was measured for cine images, and artifacts due to off-resonance effects were noted.

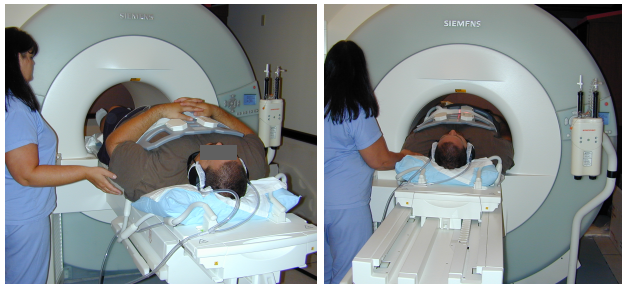

Figure 1. Siemens Magnetom ESPREE 1.5T MRI Scanner with patient weighing 404 lbs.

RESULTS

Protocols optimized to achieve equivalent spatial and temporal resolution to standard bore systems with high performance gradients had reduced speed: 9 vs 8 heartbeats breath-hold duration for retro-cine (256x160, temporal resolution=43 ms), 125 vs 111 ms/slice including SR prep (75 vs 61 ms imaging duration) for GRE-EPI perfusion (128x80), 8.7 vs 8.4 ms TR for delayed enhancement. The temporal resolution of the most demanding highly accelerated (rate=4) real-time, trueFISP sequence used for patients with arrhythmia was increased, 53 vs 42 ms (128x72). Protocols and performance specifications are listed in Tables 1-4.

Table 1. Retrogated, TrueFISP Cine Function.

ESPREE (AVANTO)

Matrix	BW (Hz/px)	Views-per-Segm	TR (ms)	temp. resol. (ms)	breath-hold(HB)
256x160	**930** (930)	**13** (15)	**3.4** (2.9)	**43.8** (43.2)	**9** (8)

Gradient:	**normal** (ESPREE) / fast (AVANTO)
FOV:	360x270 typical
Flip angle:	50 deg
Slice thickness:	6 mm
iPAT (GRAPPA) acceleration:	2 (3 segments reference lines)

Table 2. Real-time TrueFISP Function.

ESPREE (AVANTO)

Matrix	BW (Hz/px)	TR (ms)	temporal resolution (ms)
128x72	**1149** (1395)	**2.9** (2.3)	**52.56** (41.76)
160x72	**977** (1157)	**3.3** (2.6)	**59.22** (46.98)
192x72	**814** (1002)	**3.7** (2.8)	**66.42** (50.04)

Gradient:	**normal** (ESPREE) / fast (AVANTO)
FOV:	360x270 typical
Flip angle:	50 deg
Slice thickness:	8 mm
TSENSE acceleration rate:	4

Table 3. 1st Pass GRE-EPI Perfusion.

ESPREE (AVANTO)

Matrix	BW (Hz/px)	TR (ms)	imaging duration per slice (ms)	total duration per slice incl. SR prep (ms)
128x80	**1502** (1628)	**7.5** (6.1)	**75**(61)	**125** (111)

Gradient:	**normal** (ESPREE) / fast (AVANTO)
FOV:	360x270 typical
Slice thickness:	8 mm
Echo Train Length:	4
TSENSE acceleration rate:	2

Table 4. Segmented Inversion Recovery TurboFLASH Viability Imaging.

ESPREE (AVANTO)

Matrix	BW (Hz/px)	TR (ms)	imaging duration (ms) per beat
256x125	**140** (140)	**8.7** (8.4)	**218** (210)

Gradient:	**normal** (ESPREE) / fast (AVANTO)
FOV:	360x270 typical
Slice thickness:	6 mm
Views-per-segment:	25

The trueFISP FOV was shortest in the z-direction, and was measured to be 22.6±0.9 cm (m±sd, N=51). An example sagittal localizer is shown in Fig. 2 illustrating the banding artifacts due to field inhomogeneity. TrueFISP cine artifacts due to blood flow (predominantly LAX views) were minimized by moving the table position such that the aortic arch was not outside the usable trueFISP FOV (Fig. 3). Table positioning and re-positioning was straightforward. Banding artifacts for cine images are outside the heart region (Fig. 4). The worst case myocardial SNR for large patients was >10 for cine imaging using R=2 parallel imaging (SENSE g-factor was less than 1.2). Real-time imaging (TSENSE R=4 accelerated) using the Siemens TIM array (12 elements) is used for patients with arrhythmias or difficulty with breath-holding (Fig. 5). First-pass perfusion uses a 2D multi-slice accelerated GRE-EPI (Fig. 6) or TurboFLASH sequence. Viability imaging uses a segmented IR TurboFLASH (Fig. 7) or single shot TrueFISP sequence for delayed enhancement imaging.

Field inhomogeneity outside the useable FOV may in some cases cause artifacts within the FOV. Parallel imaging artifacts (phase encode wrap) were observed in several cases due to high field inhomogeneity at the edge of the FOV for trueFISP and GRE-EPI sequences. In the *k*-space methods (GRAPPA), the effective non-linear gradient in the banding region caused artifacts (infrequently), where as in image domain methods (TSENSE) artifacts resulted from GRE-EPI off-resonance ghosting. There were no parallel imaging artifacts observed using turboFLASH perfusion with TSENSE.

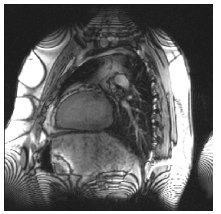

Figure 2. Sagittal TrueFISP localizer for patient weighing 404 lbs.

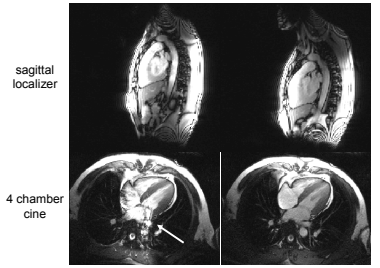

Figure 3. Effect of table positioning on off-resonance artifact for trueFISP cine.

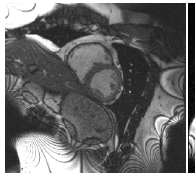

Figure 4. TrueFISP retrogated cine image for patient weighing 404 lbs.

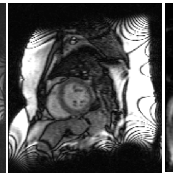

Figure 5. TrueFISP real-time image for patient weighing 333 lbs.

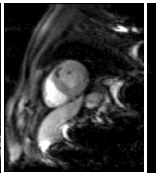

Figure 6. 1st pass-perfusion image using GRE-EPI with TSENSE.

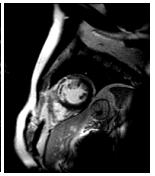

Figure 7. Delayed enhancement image using IR TurboFLASH.

CONCLUSIONS

Cardiac MR imaging with the short, wide bore 1.5T system is feasible and it was possible to image subjects that were previously too large for standard bore systems (up to 404 lbs to date). Temporal resolution equivalent to that achieved with higher performance gradients was possible within reasonable breath-hold durations. Artifacts due to field inhomogeneity were generally outside the heart region. All studies were diagnostic quality.