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2D-SENSE in isotropic slow infusion contrast-enhanced whole-heart coronary magnetic resonance angiography at 3 T

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Introduction

Slow infusion of Gd-BOPTA has been demonstrated to be effective in improving blood-myocardium CNR in whole-heart coronary MRA at 3 T[1]. However, its SNR has still been reported inferior to SSFP at 1.5 T[2]. SENSE has been previously exploited to enhance the SNR[3,4].

Purpose

To evaluate the SNR & CNR performance of 2D-SENSE enhanced whole-heart coronary MRA post contrast in comparison to a conventional T2Prep approach in patients.

Methods

Eleven patients with established cardiovascular disease were studied on a commercial 3 T Philips system with a 32-channel cardiac surface coil.

Baseline free-breathing 3D whole-heart coronary MRA with an adiabatic T2prep (TE = 50 ms)[5] was first performed. The duration of the acquisition window was adjusted to the heart-rate of the patients with a TR/TE = 3.3/1.07 ms and a flip angle(α) of 20°. 1D-SENSE (2 times accelerated) was applied in the left-right(LR) direction. The acquired isotropic voxel size was 1.3 × 1.3 × 1.3 mm^3.

Subsequently, 0.2 mmol/kg dose of Gd-BOPTA was injected at 0.3 cc/sec, and inversion-recovery (TI = 200 ms) whole-heart 2D-SENSE contrast-enhanced (CE)-MRA started 2 min after injection. Spatial/temporal resolution

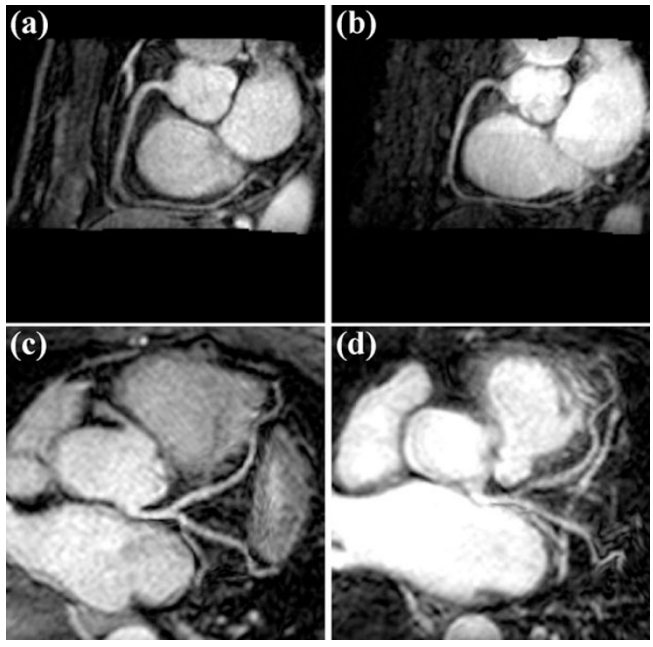

Figure 1
Multiplanar reformatted nonenhanced baseline (a and c) and 2D-SENSE CE-MRA (b and d) from a patient with myocarditis and a left ventricular ejection fraction of 20%.

Table 1: SNR, CNR and scan duration for nonenhanced and 2D-SENSE CE-MRA.

Parameter	Non enhanced whole-heart MRA (T2prep)	Whole-heart CE-MRA (Gd-BOPTA, 2D-SENSE)
SNR (blood)	37.5 ± 14.7	121.3 ± 44.0*
CNR (blood-myocardium)	14.4 ± 6.9	101.5 ± 40.8*
Scan duration (min)	9.7 ± 3.6	12.3 ± 7.7
Navigator efficiency (%)	52.3 ± 13.0	47.9 ± 10.7

*Sigificance: $p < 0.05$ vs. T2prep values (paired two-sided Student *t*-test)

as well as volumetric coverage/scanning time remained unchanged relative to the baseline scan. However, post-contrast, a SENSE acceleration factor of 2 × 2 was used in the FH and LR directions. Rather than using 2D-SENSE to abbreviate scanning time, it was exploited to maximize SNR post-contrast by minimizing the signal readout bandwidth (TR/TE = 6.6/1.71 ms) and by optimizing α(= 25°). Based on a numerical simulation, the 2D-SENSE CE-MRA should improve SNR more than 2-fold vs. baseline.

Both scans were combined with a 3D noise scan (30 sec duration) to support SNR and CNR quantification on images acquired with SENSE. SNR, CNR, vessel length and sharpness were quantified and compared for the pre- and post-contrast acquisitions.

Results

The quantitative results are shown in Tables 1 &2. 2D-SENSE CE-MRA resulted in a 3-fold/7-fold increase in SNR/CNR vs. baseline. However, this did not translate into improved vessel sharpness or longer visible vessel length. Representative images from a patient are shown in Figure 1. Figure 2 shows 2D-SENSE CE-MRA and the cor-

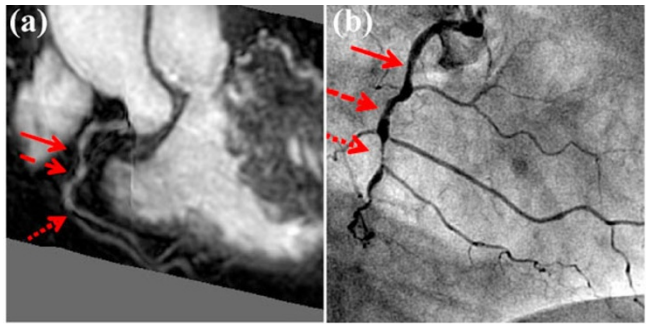

Figure 2
Comparison of multiplanar reformatted 2D-SENSE CE-MRA image (a) and the corresponding X-ray angiogram (b) from a patient with RCA disease. Three locations of stenoses are indicated with solid, dashed and dotted arrows. The locations of the luminal narrowing in the proximal and mid RCA on the 2D-SENSE CE-MRA agree well with those seen on the x-ray angiogram.

Table 2: Vessel length and vessel sharpness for nonenhanced and 2D-SENSE CE-MRA.

Parameter		Non enhanced whole-heart MRA (T2prep)	Whole-heart CE-MRA (Gd-BOPTA, 2D-SENSE)
Vessel length (cm)	LM + LAD	6.8 ± 2.1	7.5 ± 2.3
	LCx	3.4 ± 0.8	3.9 ± 1.1
	RCA	11.8 ± 3.1	10.6 ± 3.7*
Vessel sharpness (%)	LM + LAD	50.2 ± 6.6	46.7 ± 6.0
	LCx	51.1 ± 8.7	42.7 ± 7.5*
	RCA	51.5 ± 7.4	52.0 ± 11.1

*Sigificance: $p < 0.05$ vs. T2prep values (paired two-sided Student *t*-test)
LM = left main artery, LAD = left anterior descending artery, LCx = left circumflex, RCA = right coronary artery.

responding X-ray coronary angiogram from a patient with RCA disease.

Conclusion

Slow-infusion in combination with 2D-SENSE could be successfully exploited to substantially improve SNR and CNR in isotropic whole-heart coronary MRA at 3 T. Further methodological advances will help translate the considerable SNR and CNR advantage into an improved visible vessel length, vessel conspicuity and spatial resolution. This will be critical for larger patient studies that include a direct comparison with the x-ray coronary angiography.

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