Prospective intraindividual comparison between highly accelerated breath hold non-contrast ECG-gated balanced steady state free precession MRA and ECG-gated CT angiography

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Purpose

CTA is the first line diagnostic modality for assessment of thoracic aortic pathology[1], and using electrocardiographic gating (eCTA), provides clear depiction of the aortic root and ascending aorta. However, it utilizes nephrotoxic contrast, of concern in patients with renal impairment[2], and imparts an ionizing radiation dose between 1.9 - 43mSv[3,4]. Recently, an ECG-gated 3D breath hold non-enhanced balanced steady state free precession (bSSFP) MRA sequence (NE MRA) has been described, that utilizes two dimensional image acceleration with acquisition of coil sensitivity and MRA data during different phases of the cardiac cycle[5,6], markedly decreasing acquisition times compared with free-breathing bSSFP MRA[7]. We evaluate the performance of NE MRA in a clinical population, with eCTA as the reference standard.

Methods

16 patients (12 males, 4 females, mean 59.4, range 20-86yrs), referred for known or suspected aortic disease underwent NE MRA at 1.5T (Avanto, Siemens Healthcare) with a 6-channel body coil and posterior spine elements. NE MRA parameters were: TR/TE 3.5/1.5 ms, FA 70°, true voxel size 1.6x1.6x2.0mm^3, FOV 315 x 420 mm, 6/8 slice and phase partial Fourier, 60 partitions, acquisition time 24 RR intervals, trigger pulse 1, trigger delay 500ms, acceleration factor 2 (partition) x 3 (PE).

eCTA was performed in all patients within 2 weeks of NE MRA with a 64-detector scanner (LightSpeed VCT i, GE Healthcare), with 0.625mm slice thickness, 100-120kVP, 80-120mL of Iohexal 350 (Omnipaque, GE Healthcare) intravenously at 3.5-4.5ml/s, dictated by body habitus. Prospective ECG-gating (n=8) was used for heart rate (HR) <65bpm, acquired in 12-16 RR intervals with beam collimation 40mm. Retrospective gating was used for HR≥65 bpm (n=8), with pitch for retrospective scanning HR-dependent (0.18-0.24). Radiation dose was recorded for eCTA.

Table 1. Aortic Dimensions (mean ± SD) in mm

Aortic segment	NE MRA	eCTA	p-value
Annulus	24.6 ± 5.98	26.57 ± 3.88	0.082
Sinuses of Valsalva	37.6 ± 10.59	38.67 ± 10.38	0.18
Sinotubular junction	34.99 ± 7	35.49 ± 6.52	0.23
Ascending aorta	42.23 ± 12.22	42.62 ± 11.32	0.56
Aortic arch	29.28 ± 6.87	30.31 ± 6.28	0.03
Descending aorta	29.08 ± 8.07	30.55 ± 8.7	0.008
Diaphragmatic aorta	25.44 ± 6.23	26.6 ± 6.93	0.02

Anonymized NE MRA and eCTA images were interpreted in random order by an experienced cardiovascular radiologist. Aortic pathology, diagnostic confidence and image quality were recorded for each patient. Aortic dimensions were evaluated in 7 defined segments (annulus, sinuses of Valsalva, sinotubular junction, ascending aorta, arch, descending aorta, diaphragmatic aorta). Diagnostic confidence and image quality were scored on a 5-point Likert scale (1=worst, 5=best). Categorical variables were compared with the Wilcoxon signed-rank test and aortic dimensions compared with the paired Student t-test, with $p<0.05$ considered significant.

Results

All patients successfully completed both NE MRA and eCTA, with 14 in sinus rhythm, 1 in slow atrial fibrillation, and 1 with frequent ectopics. At eCTA, aortic aneurysm (n=8), dissection (n=4, 1 Type A dissection status post ascending aortic graft repair), aortic coarctation (n=2), Sinus of Valsalva aneurysm (n=1) and 1 normal study were found, all identified with NE MRA (Figs 1 and 2). A small dissection flap post ascending aortic graft repair seen on eCTA, was not identified with NE MRA. B_0 inhomogeneity led to signal loss in the proximal left subclavian artery in one patient, misinterpreted as vessel stenosis. Diagnostic confidence was high for NE MRA, and not significantly different from eCTA (4.8±0.5 vs. 5±0 respectively, p=0.18). Mean image quality (3.5±1.2) was diagnostic for NE MRA; however, results were significantly superior for eCTA (4.5±0.7, p<0.001). There were small but statistically significant differences in aortic dimensions for the arch, descending and diaphragmatic aorta (refer to Table 1). Mean effective dose for eCTA was 13.9mSv (mean 6.4mSv for prospectively-gated and 21.4mSv for retrospectively-gated acquisitions).

Discussion/ Conclusion

In our initial experience, NE MRA identified all major aortic pathology with high diagnostic confidence. Although significant differences in aortic dimensions were observed in distal segments, average differences were small, and of questionable clinical impact. Diagnostic image quality was achieved, although it remained inferior to the reference standard. The breath-hold NE MRA technique evaluated offers a promising alternative to eCTA, free of both ionizing radiation and exogenous contrast, with potential clinical application in young patients, particularly where long-term surveillance is required.

***Fig 1**. 64 year-old female with prior aortic coarctation repair A) NE MRA and B) eCTA demonstrate recurrent narrowing (arrows)*

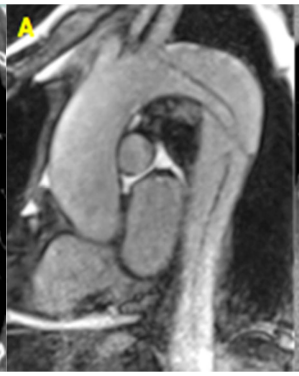

***Fig 2**. 38 year-old male with acute chest pain A) NE MRA and B) images demonstrate Type B aortic dissection*

References

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