Single breath-hold non-contrast thoracic mra using highly-accelerated parallel imaging with a 32-element coil array

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Purpose
To evaluate the feasibility of performing non-contrast thoracic MRA with isotropic spatial resolution within a single breath-hold.

Background
Contrast-enhanced 3D magnetic resonance angiography (CE-MRA) provides accurate diagnosis of aortic disease [1-4]. ECG-gated CE-MRA of the thoracic aorta is challenging, due to competing demands of high spatial resolution while imaging in a narrow window of the cardiac cycle within a breath-hold. In addition, nephrogenic systemic fibrosis in patients with impaired renal function is a concern with gadolinium-based contrast agents [5]. Non-contrast ECG-gated MRA (NC-MRA) is a potential alternative [6], especially for patients with poor intravenous access or contraindications to gadolinium use. Navigator-gated NC-MRA can take approximately 10 minutes [6]. We propose to perform breath-hold, ECG-gated NC-MRA (BH NC-MRA) using highly-accelerated parallel imaging with a 32-element coil array.

Methods
Following informed consent, 10 subjects (7 controls, 3 patients; 6 male, mean age=35.1 ±17.0 years) were imaged on a 1.5Tscanner (Siemens, Avanto) with BH NC-MRA followed by CE-MRA. Imaging parameters for BH NC-MRA using balanced steady state free precession (b-SSFP) with T2 and fat-suppression preparation pulses were: TR/TE 2.3/1.6ms, FA70°, FOV 400x400x64mm, voxel size 1.6x1.6x1.6mm3, 2D GRAPPA acceleration of 3x2, segments 48, 6/8 partial Fourrier in both phase encode and partition directions, partition oversampling 20%, mean scan time 19.4±4.1s. Both coil sensitivity (early systole) and MRA (mid diastole) data were acquired in the same breath hold (Figure 1). Pre- and post-contrast ECG-gated CE-MRA used similar parameters to achieve matched spatial resolution, TR/TE 3.6/1.1ms, FA 17°, BW 330Hz/pixel, 1D GRAPPA acceleration factor 2, mean scan time 39.4±10.5s. Gd-DTPA 0.15 mmol/kg at 2cc/sec was administered with arterial timing based on a timing bolus. Source and subtracted images (for CE-MRA) were reviewed in blinded fashion by a cardiologist and a radiologist. Image quality was scored (0-4; non-diagnostic to excellent) for 4 aortic segments (Table 1). Severity of artifacts was also evaluated (0-4; none to high).

Results
Figure 2 shows representative CE-MRA and BH NC-MRA images. For the 10 subjects studied, there was no significant difference in image quality and artifact scores (p>0.05), with diagnostic quality image scores for all evaluated segments (Table1).

Figure 1 Single BH NC-MRA with the coil sensitivity and image data acquired at two different cardiac phases in the same cardiac cycle.
Conclusions

This study demonstrates the feasibility of performing highly accelerated single BH NC-MRA with isotropic spatial resolution and diagnostic image quality. It has potential benefits of short scan time and repeatability without need for exogenous contrast, providing rapid, safe, entirely non-invasive assessment of the thoracic aorta.

Table 1 Comparison of image-quality and overall artifact scores between CE-MRA and NC-MRA

<table>
<thead>
<tr>
<th>Aorta Segmentation</th>
<th>Score Mean +/- SD</th>
<th>Wilcoxon Test p-value</th>
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<tbody>
<tr>
<td></td>
<td>CE-MRA</td>
<td>NC-MRA</td>
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<tr>
<td>Aortic Root</td>
<td>2.8 ± 0.48</td>
<td>2.7 ± 0.71</td>
</tr>
<tr>
<td>Ascending Aorta</td>
<td>3.15 ± 0.41</td>
<td>2.95 ± 0.69</td>
</tr>
<tr>
<td></td>
<td>0.41</td>
<td>0.69</td>
</tr>
<tr>
<td>Aorta Arch</td>
<td>3.6 ± 0.45</td>
<td>3.4 ± 0.61</td>
</tr>
<tr>
<td>Descending Aorta</td>
<td>3.75 ± 0.26</td>
<td>3.7 ± 0.48</td>
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<tr>
<td></td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>Overall Artifact</td>
<td>1.1 ± 0.46</td>
<td>1.5 ± 0.78</td>
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Figure 2 Multi planar reconstruction of A) contrast-enhanced MRA and B) noncontrast enhanced MRA in a patient (59yr, Female) with aneurysm of the aortic root.

References
