Aortic Aneurysm Pulsatile Wall Motion Imaged by Cine MRI: a Tool to Evaluate Efficacy of Endovascular Aneurysm Repair?

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Objectives: to evaluate cine MRI as a means of determining the two-dimensional pulsatile wall motion (2D-PWM) of abdominal aortic aneurysm (AAA).

Design: prospective study of 21 patients with AAA. 2D-PWM was defined as change in cross-sectional area.

Results: the median diastolic area was 28 cm² (intraquartile range, IQR, 22–31 cm²) and the median (IQR) 2D-PWM was 0.25 (0.10–0.40) cm². Assuming that the AAA is circular in cross-section this represents a median (IQR) diameter increase of 0.3 (0.1–0.4) mm. However, local wall displacements up to 2 mm were present in varying directions, without significant change in surface area.

Conclusion: AAA PWM is negligible and may not therefore be a potential tool to assess efficacy of endovascular aneurysm exclusion.

Key Words: Endovascular; Aneurysm; Cine MRI; Pulsatile wall motion.

Introduction

The durability of endovascular aneurysm repair (EVAR) is increasingly being called into question. A means of predicting and identifying late endoleak is urgently required.1-10

Direct pressure measurements are limited by their invasive nature.11-14 Uni-dimensional pulsatile wall motion (PWM) has been proposed as an alternative.15 In this institution, cine MRI has been shown to be an excellent tool to measure PWM of the heart and great vessels in two dimensions.16,17 To date, no cine MRI acquisition studies have been published monitoring wall motion of aortic aneurysms. The aim of this study was to evaluate cine MRI as a standardised, operator dependent tool to measure 2D-PWM in abdominal aortic aneurysms (AAAs).

Materials and Methods

Twenty-one patients (17 men) of median age (range) 74 (57–87) years with AAA of median (range) diameter 62 (42–80) mm underwent cine MRI. The technical details are shown in Table 1. At the point of greatest cross-sectional area cine images were obtained at a range of 12 per heartbeat.

The images were processed on a Sun Sparcstation (Sun Microsystems, Mountain View, CA, U.S.A.) using

Table 1. Technical specifications.

<table>
<thead>
<tr>
<th></th>
<th>Standard resolution (n = 11)</th>
<th>High resolution (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanner</td>
<td>1.5T Siemens Vision</td>
<td>1.5T Siemens Sonata</td>
</tr>
<tr>
<td>Pulse sequence</td>
<td>Gradient echo</td>
<td>Steady state free precession</td>
</tr>
<tr>
<td>Excitation angle</td>
<td>25°</td>
<td>60°</td>
</tr>
<tr>
<td># Phase-encoding lines/heartbeat</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Acquisition time window</td>
<td>100 ms</td>
<td>72 ms</td>
</tr>
<tr>
<td>Temporal resolution</td>
<td>50 ms (echo-sharing)</td>
<td>72 ms (no echo-sharing)</td>
</tr>
<tr>
<td># Acquisitions</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Slice thickness</td>
<td>6 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Echo time</td>
<td>4.8 ms</td>
<td>2.48 ms</td>
</tr>
<tr>
<td>Receiver bandwidth</td>
<td>195 Hz/pixel</td>
<td>574 Hz/pixel</td>
</tr>
<tr>
<td>Field of view</td>
<td>240 × 320 mm</td>
<td>227 × 280 mm</td>
</tr>
<tr>
<td>Acquisition matrix</td>
<td>162 × 256 pixels</td>
<td>416 × 512 pixels</td>
</tr>
<tr>
<td>Pixel size</td>
<td>1.48 × 1.25 mm</td>
<td>0.55 × 0.55 mm</td>
</tr>
</tbody>
</table>

In the table the technical specifications are given for the cine MRI with standard resolution, and the cine MRI with high resolution.

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Fig. 1. Transverse sections of an aortic aneurysm imaged by high resolution cine MRI with added aneurysm wall contours. (a) end-diastole, red contour; (b) peak-systole, yellow contour; (c) Both contours combined. Note the translation (± 2 mm) in the anterior direction without any noticeable change in cross-sectional area.

the “MASS” software package (Dept. of Radiology, Leiden University Medical Center, Leiden, The Netherlands).

In patients where the AAA could not be delineated from the vertebral column a different slice 10 mm above or below was selected. The AAA contour was traced twice by two independent blinded observers. 2D-PWM was defined as the difference between the smallest (end-diastolic, ED) and largest (peak-systolic, PS) cross-sectional area. Left brachial pressure was measured using sphygmonanometry.

Statistical analyses were performed with SPSS software. A value of $p<0.05$ was considered statistically significant. The reliability coefficient of the 2D-PWM measurements was calculated for the means of the two observers.$^{18}$

**Results**

The median (IQR) 2D-PWM was 0.25 (0.1–0.4) cm$^2$ and the median (IQR) ED area was 28 (22–31) cm$^2$. The
reliability coefficient for the two observers was 0.81. There was no significant difference between the 2D-PWM measured using the standard and high resolution techniques. The 2D-PWM represents only a 1% increase in cross-sectional area and, assuming the transverse section is circular, only a 0.3 mm increase in median diameter. However, localised wall displacements (up to 2 mm) in various directions were observed (Fig. 1). The median MAP was 107 mmHg in the standard resolution and 100 mmHg in the high resolution group (p = 0.12). Median pulse pressures were 60 vs 68 mmHg, respectively (p = 0.47).

Discussion

Ultrasound and MRI allow indirect intra-vascular pressure measurement to be made on the basis of diameter, cross-sectional area and volume changes.18–24 Several groups have previously studied AAA.25–27 One application of this technology may be the detection of endoleak following EVAR.28 In the present study the PWM as determined by cine MRI (about 1%) is less than that found in ultrasound-based studies.15,26 (about 4%). There may be several reasons for this. Ultrasound-based techniques are uni-dimensional and assume equal wall movement in all directions.15,23 Furthermore, they cannot distinguish this PWM from movement of the whole AAA. And lastly, pressure from the transducer may affect distensibility.

This study was initiated to determine if aneurysm wall motion can be accurately monitored by cine MRI to possibly determine efficacy of EVAR.28–31 However, the true 2D-PWM is so small that it falls within the variation of measurements.

In conclusion, using high resolution, 2D cine MRI, we have demonstrated that true pressure related pulsatile aneurysm wall motion is negligible and therefore not useful as a potential tool to assess efficacy of endovascular aneurysm exclusion.

References

26 Lanne T, Sonesson B, Bergqvist D, Bengtsson H, Gustafsson A. W. F. Vos et al.

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