A Study on Errors of Magnetic Resonance Flow Measurement by Slice Misalignment in Ascending Aorta

Ho NamKoong, R.T. (MR)

Seoul National University Hospital, Korea
Flow Measurement in CMR
- phase contrast with ECG triggering
- image plane positioned **perpendicular** to the vessel of interest

If not a right angle, it can cause the errors of flow data
\[ F_{\text{measurement}} = F_{\text{true}} \times \cos \theta \]

\( F = \text{flow} \)

\( \theta = \text{the angle of slice misalignment,} \)

\( F_{\text{true}} = \text{the flow without inclination (perpendicular to the vessel)} \)

\( (\cos 10=0.984, \cos 20=0.939, \cos 30=0.866) \)
Introduction

- Slice Misalignment in clinics
Purpose

- We investigated the errors of flow measurement by slice misalignment for ascending Aorta in patients clinically.
Material & Methods

- 23 patients (7 women, 16 men, mean age; 55.6±19 years old)
- 1.5T MRI (Magnetom Sonata, Siemens, Germany)
- November to December, 2009
- Phase Contrast FLASH 2D with retrospective ECG gating
  \[ \text{TR/TE} = 41/3.2\text{ms}, \text{FA} = 30^\circ, \text{FOV} = 300\text{mm}, \]
  spatial resolution \((1.3 \times 1.2 \times 5\text{mm}^3)\).
**Material & Methods**

- VENC / phases = 150cm/sec / 20phases (calculated)
- Different angles (0°, 10°, 20°, and 30°) of slice inclination tilted to the ascending Aorta in each patient prospectively
Material & Methods

- Argus (syngo MR A30)

Re-phase

Magnitude

Phase contrast
**Material & Methods**

- Average velocity (Avg. V),
- Net forward volume (Net FV),
- Net forward volume / body surface area (Net FV/BSA),
- Average area (Avg. A)
Material & Methods

- Percent error (%) = \( \frac{(\text{with} - \text{without inclination})}{\text{without inclination}} \times 100 \)

- Percent errors were calculated and compared.
- Paired \( t \)-test
## Percent errors

<table>
<thead>
<tr>
<th>Angle of inclination</th>
<th>10°</th>
<th>20°</th>
<th>30°</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. V</td>
<td>-7.77 ± 10.44</td>
<td>-12.78 ± 11.78</td>
<td>-21.05 ± 13.74</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Net FV</td>
<td>-3.09 ± 7.45</td>
<td>-6.08 ± 7.42</td>
<td>-9.55 ± 9.44</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Net FV/BSA</td>
<td>0.73 ± 20.95</td>
<td>-6.10 ± 7.41</td>
<td>-9.55 ± 9.45</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Avg. A</td>
<td>1.74 ± 4.55 (p=0.08)</td>
<td>4.97 ± 5.71</td>
<td>11.67 ± 7.48</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Unit: %
Results

- Percent errors

<table>
<thead>
<tr>
<th>Avg V</th>
<th>Net FV</th>
<th>FV/BSA</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>D10</td>
<td>D20</td>
<td>D30</td>
<td></td>
</tr>
</tbody>
</table>
Results

- Avg. A in 0°, 10°, 20°, and 30° of slice inclination
In the absence of partial volume errors, a misalignment of as much as $20^\circ$ will produce only a 6% error, whereas a more realistic misalignment of $5^\circ$ causes an error $< 1\%$. – Hamilton CA et al (1994), *JMRI* 4:752-755

Flow measurements are most precise if the imaging plane is perpendicular to the vessel of interest and flow encoding is set to through-plane flow. – Lotz et al *Radio-Graphics* 2002; 22:651-671

Deviation of $\pm 15^\circ$ from the orthogonal imaging plane is tolerable for estimation of flow. – Tang C et al *JMRI* 1993; 3:377-385

Mean percent error ranged from -3.8% to 4.2%. / all results remaining within 6% error. – Greil et al *JMRI* 2002; 15:47-54
Conclusions

- The percent error of Net FV and Net FV/BSA were relatively acceptable with < 10% errors within $30^\circ$ of slice inclination in patients.

  (Flow = average velocity x cross-sectional area)

  The Avg. A was increased by slice inclination.

Slice should be positioned within $10^\circ$ of inclination in order to keep less than 5% errors.
Thank You!

www.jamesho.tistory.com