3D Cardiac Imaging

Raja Muthupillai, PhD
Department of Diagnostic and Interventional Radiology
St. Luke’s Episcopal Hospital
Houston, TX

Disclosures

• Research Support: Philips Healthcare

This presentation contains information regarding the use of Gadolinium based CA which is not FDA approved for CV imaging
2D Imaging Versus 3D Imaging

3D Cardiac Imaging: Why?

<table>
<thead>
<tr>
<th></th>
<th>2D-Imaging</th>
<th>3D-Imaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Time</td>
<td>$N_y \times N_x \times TR$</td>
<td>$N_y \times N_x \times TR \times N_z$</td>
</tr>
<tr>
<td>SNR/voxel</td>
<td>$\sqrt{N_y}$</td>
<td>$\sqrt{N_y} \sqrt{N_z}$</td>
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<tr>
<td>Typical Slice Thk</td>
<td>$&gt; 3$ mm</td>
<td>$&lt; 1$ mm (possible)</td>
</tr>
<tr>
<td>Blood-Muscle CNR</td>
<td>High (Inflow effect)</td>
<td>FoV$_{ul}$ Dependent</td>
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3D Cardiac Imaging

Outline

• A systematic approach toward a coronary MRA protocol

• Two common approaches for cMRA

• Typical Problems and Solutions
Coronary MRA: Requirements

- Small
- Small
- Tortuous
- Tortuous
- Motion
- Motion
- Coronary Flow
- Coronary Flow
- Epicardial Fat
- Muscle
- High Resolution (< mm)
- High Resolution (< mm)
- Large Coverage
- Large Coverage
- Gating (Cardiac/Respiratory)
- Gating (Cardiac/Respiratory)
- Acq. Duration
- Acq. Duration
- Blood to Fat Contrast
- Blood to Muscle Contrast

Goals of Coronary MRA

1. Extend Acquisition Time
2. Maximize Blood (Arterial) Contrast
I. Respiratory Motion and cMRA

Breath-holding?

- BH duration: 16-22 heartbeats
- Acq. Duration: 2200 - 3000 ms
- Num PEs: 550-750 (TR=4 ms)
- One or two high resolution slices / breath hold

Multiple Breathholds?

![Position of diaphragm](image1)

- BH1, BH2, BHn

Pencil-Beam Respiratory Motion Tracking

- Freely Movable
- Low Flip Angle excitation
- Real time tracking

![Image of pencil beam tracking](image2)
Real-Time Respiratory Tracking/Gating: Accept /Reacquire Algorithm

Navigators extend Acquisition time beyond breathholding capacity

II. Contrast Preparation for cMRA

- Epicardial Fat
  - Fat Suppression
- Cardiac Muscle
- Arterial Blood
- Venous Blood
Effect of T₂ Preparation:

![Graph showing the effect of T₂ preparation on signal difference in Art-Ven and Art-Mus.](image)

Typical cMRA Protocol:

![Diagram showing a typical cMRA protocol with T₂ prep, NAV Fat Sat, 3-D TFE / SSFP.](image)
Targeted cMRA protocol

N = 109
Single Vendor
Sub Lingual
ISDN

Prevalence of disease by invasive angiography

<table>
<thead>
<tr>
<th>Column</th>
<th>LM</th>
<th>LAD</th>
<th>LCx</th>
<th>RCA</th>
<th>Any</th>
<th>LM / 3 VD</th>
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<tr>
<td>Sensitivity</td>
<td>67</td>
<td>88</td>
<td>53</td>
<td>93</td>
<td>93</td>
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<tr>
<td>Specificity</td>
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<td>52</td>
<td>70</td>
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<tr>
<td>Prevalence</td>
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<td>65</td>
<td>67</td>
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<td>56</td>
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<td>69</td>
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<td>NPV</td>
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<td>86</td>
<td>86</td>
<td>94</td>
<td>81</td>
<td>100</td>
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</tbody>
</table>
Whole Heart 3D cMRA

- Similar to prior cMRA
- SSFP readout
- In-plane resolution
  1.0 mm x 1.0 mm
- SENSE factor x 2

CB Higgins et al. MRM 2003;50:1223-1228
Sakuma, et al. JACC, 2006

Sakuma et al.:  
n = 131 pts; Scan Time: 12.9 ± 4.3 min (5.8 – 28.8 min)  
86% Completion rate; Mean weight: 65 kg
Advances in Whole Heart SSFP cMRA

- 1.5 T scanner; 32 Channel coil
- SENSE factor 2 x 2
- Voxel 1 x 1 x 1.5 mm
- Magnetization prepared, fat – sat 3-D SSFP
- Mean scan time 240 ± 40 secs

K Nehrke et al. JMRI 2006;23:752-756

Whole Heart coronary MRA

32 Channel coil/SENSE factor 4;
Scan Time: 5 min @ 70% efficiency

Courtesy: Dr. Benjamin Cheong, SLEH.
Clinical Applications: Coronary MRA

Proximal Coronaries

Coronary Anomalies

Tissue Characterization

Typical Problems and Solutions

1. **Significant Motion** artifacts in Image

   ✓ Check if Data Acquisition is at correct cardiac phase
   ✓ Acquire a High Temporal Resolution Cine to select Appropriate cardiac phase

Sodickson, et al, ISMRM 1997
Typical Problems and Solutions

1. Patient Falls asleep, and Breathing position has changed
   - Enable Navigator Drift Correction (if available)
   - Speed up Acquisition (Use Parallel Imaging)

Typical Problems and Solutions

2. Navigator efficiency too low
   - Enable Motion Adapted Gating (if available)
   - Restrict coverage/Use SENSE

Muthupillai, et al. AJR, 2006
Typical Problems and Solutions

Coronary MRA at 3.0T

- Use TFE readout versus SSFP
  Sensitive to off-resonance;
  Long TR due to spatial res demands

- T2 prep less robust; IR-prep post-contrast

Stuber et al. MRM 2002
Thank you!