Coronary MR Angiography

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Advantages of coronary MRA

• No ionizing radiation
• No contrast injection
• No interference by calcification

Weakness of MRI

• Substantially slower than 64-slice MDCT
• Acquisition time of 3D volume (FOV 32x32x20cm, acquisition resolution 0.6x0.6x0.6mm, no ECG gating)
  - 64-slice MDCT < 2 sec.
  - MRI > 2 min.
    40,960 phase encoding steps
    TR 3ms, SENSE factor 2, half scan

MR detection of coronary artery stenoses

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Reference</th>
<th>Method</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manning WJ</td>
<td>NEJM 1993;328:828</td>
<td>2D breath-hold</td>
<td>90</td>
<td>92</td>
</tr>
<tr>
<td>Duerinckx AJ</td>
<td>Radiology 1994;130:731</td>
<td>↑</td>
<td>63</td>
<td>82</td>
</tr>
<tr>
<td>Van Goons RJ</td>
<td>Radiology 2000;217:270</td>
<td>3D breath-hold</td>
<td>68</td>
<td>97</td>
</tr>
<tr>
<td>Regenfus M</td>
<td>JACC 2006;36-44</td>
<td>↑</td>
<td>94</td>
<td>57</td>
</tr>
<tr>
<td>Woodard PK</td>
<td>AJR 1999;170:883</td>
<td>3D navigator, retrospective</td>
<td>73</td>
<td>N/A</td>
</tr>
<tr>
<td>Sandstede JJ</td>
<td>AJR 1999;172:135</td>
<td>↑</td>
<td>81</td>
<td>89</td>
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<tr>
<td>Sardanelli F</td>
<td>Radiology 2000;214:858</td>
<td>↑</td>
<td>82</td>
<td>89</td>
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<tr>
<td>Kim WY</td>
<td>NEJM 2001;345:1863</td>
<td>3D navigator, prospective</td>
<td>93</td>
<td>42</td>
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<tr>
<td>Bogaert J</td>
<td>Radiology 2002;220:779</td>
<td>↑</td>
<td>50</td>
<td>90</td>
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<tr>
<td>Keller J</td>
<td>JACC 2005;46-92</td>
<td>↑</td>
<td>75</td>
<td>77</td>
</tr>
</tbody>
</table>

1993-2005 Sensitivity 50-94%, Specificity 42-97%

Breath-hold 2D coronary MRA

2D Breath-hold GRE Cartesian

3D Resp. gating SSFP Radial sampling

Sakuma H. AJR 1994; 163:533-537

Respiratory gated 3D coronary MRA

2D Breath-hold GRE Cartesian

3D Resp. gating SSFP Radial sampling

Sardanelli F. Radiology 2000;214:858
Sakuma H. Invest Radiol. 1999;34:503
Breath-hold 3D coronary MRA

- 3D Breath-hold
- GRE
- Cartesian sampling
- SSFP
- Radial sampling

Whole Heart Coronary MRA

- 3D Breath-hold
- GRE
- Cartesian sampling
- SSFP
- Radial sampling

Free-breathing 3D coronary MRA

- Navigator echo
  - prospective real-time respiratory gating
  - gating window = +/- 2.5mm
  - adoptive motion correction

Whole heart coronary MR angiography using steady state free precession

- 3D Breath-hold
- GRE
- Cartesian sampling
- SSFP
- Radial sampling

3D Breath-hold Coronary MRA - Multi-center study -

- Breath-hold 3D FIESTA
- 1.1x1.2x2 mm resolution
- 77%(79/103) coronary arteries visualized
- In 79 arteries visualized, 82% showed diagnostic image quality (Grade 3-4)

Radiology 2005;235:1025-1030

Whole heart coronary MRA in 131 patients using optimized acquisition window in the cardiac cycle

- During diastole
  - 83/131 (63.3%) patients
  - HR = 65.1 BPM ± 9.4
  - Window = 152 ms ± 67

- During systole
  - 48/131 (36.7%) patients
  - HR = 83.2 BPM ± 9.5
  - Window = 98 ms ± 26

Sakuma H. J Am Coll Cardiol 2006 (in press)
**Initial results**

- Imaging time  
  13.8 min \( \pm 3.8 \) (range 6.8-23.8 min)
- Imaging completed  34/39 (87.2%)
- Study success rate  32/39 (82.1%)
  High quality (score \( \geq 3 \) in 4 point-scale) images in all three major coronary arteries

*Sakuma H, Ichikawa Y, Radiology 2005;237:316*
54-year-old man with LCX stenosis (HR = 78/min.)

- A. Curved multiplanar reconstruction of whole heart coronary MRA.
- B. Volume rendering of whole heart coronary MRA.
- C. Catheter X-ray coronary angiography.

Detection of significant coronary artery stenoses with whole heart coronary MRA using optimal acquisition window in the cardiac cycle in 113 patients

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
<th>Accuracy, %</th>
</tr>
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<tbody>
<tr>
<td>Per patient</td>
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<tr>
<td>Per vessel</td>
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<tr>
<td>RCA</td>
<td>85(65-95)</td>
<td>95(88-98)</td>
<td>95(65-95)</td>
<td>95(88-98)</td>
<td>83(86-97)</td>
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<tr>
<td>LM</td>
<td>NA</td>
<td>99(93-100)</td>
<td>NA</td>
<td>100(96-100)</td>
<td>99(93-100)</td>
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<tr>
<td>LCX</td>
<td>70(47-86)</td>
<td>92(86-97)</td>
<td>82(62-96)</td>
<td>93(85-97)</td>
<td>91(84-95)</td>
</tr>
</tbody>
</table>

Study success rate = 86% (113/131)
All arteries with diameter of ≥2mm on coronary angiography were evaluated.


How we use coronary MRA in the era of 64-slice MDCT.

64-slice MDCT angiography

76M RCA occlusion

Light Speed VCT 64, Virtual Place
Matsusaka Central Hospital, Mie, Japan

Coronary MRA vs. CTA
- Kefer J, JACC 2005;46:92
- Coronary MRA - free breathing, 3D balanced TFE on targeted double oblique slices

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
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<tbody>
<tr>
<td>Coronary MRA</td>
<td>75%</td>
<td>77%</td>
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<tr>
<td>16-slice CTA</td>
<td>82%*</td>
<td>79%*</td>
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</tbody>
</table>

* p=N.S.

Diagnostic accuracy of CTA and MRA in detecting patients with significant CAD

<table>
<thead>
<tr>
<th>Whole heart coronary MRA</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jahnke C, Eur Heart J 2005;26:2313</td>
<td>78%</td>
<td>91%</td>
</tr>
<tr>
<td>Sakuma H, JACC 2006 (in press)</td>
<td>82%</td>
<td>90%</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>64-slice MDCT</th>
<th>Sensitivity</th>
<th>Specificity</th>
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</thead>
<tbody>
<tr>
<td>Mollet NR. Circulation 2005;112:2318</td>
<td>100%</td>
<td>92%</td>
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<tr>
<td>Pugliese S. Eur Radiol 2005;16:1</td>
<td>100%</td>
<td>90%</td>
</tr>
<tr>
<td>Leber AW. JACC 2005;46:155</td>
<td>90%</td>
<td>95%</td>
</tr>
</tbody>
</table>
How we use coronary MRA in the era of 64-slice MDCT.

1. Anomalous coronary artery
2. Coronary aneurysm in Kawasaki disease.
3. Patients with renal failure.
4. Patients with heavy coronary calcification.
5. As a part of one-stop-shop CMR study
6. Screening CAD in asymptomatic subjects

31-year-old man, VT after exercise

Whole heart coronary MRA

71-year-old man, chest pain on effort
Coronary CT angiography was performed using 64-slice MDCT

Whole heart coronary MR angiography

MRA as a part of one-stop-shop cardiac MR study

Acknowledgements

Matsusaka Central Hospital
Department of Radiology
Yasutaka Ichikawa, MD
Shuji Chino, MD
Tadanori Hirano, MD
Tadanori Hirano, MD
Chikai Shoji, RT
Tetsuya Ochiai, RT
Katsuyoshi Makino, MD
Philips Medical Systems

Mie University Hospital
Department of Radiology
Nanaka Ishida, MD
Kan Takeda, MD
Shinichi Takase, RT
Genji Asanuma, RT
Department of Cardiology
Tairo Kurita, MD
Katsuya Onishi, MD
Masaaki Ito, MD

X-ray coronary angiography

Volume rendering Curved MPR
Coronary CT Angiography (GE VCT64)

Volume rendering Curved MPR

Stress-rest perfusion MRI Perfusion
Delayed enhanced MRI Viability
Whole heart 3D coronary MRA Morphology

Survey & SENSE reference
60min 20min 30min 40min 50min 60min
Stress bFFE cine MRI High-res cine MRI Whole heart coronary MRA
Refl Perfusion MRI Delayed enhanced MRI