Coronary MRI: State-of-the-Art

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2nd Imaging and Physiology Summit - Seoul, Korea
Presenter Disclosure Information

The following relationships exist related to this presentation:

**Research Support** – GE Healthcare

**Scientific Advisory Board** – Kowa Pharmaceuticals

**Advisor** – Gilead, CoRepair

**Honoraria** – Medtronic

*Presentation includes investigational MRI software, hardware, and contrast agents not yet FDA-approved or “off-label”.*
Advantages of Coronary MRA

- No radiation
- Contrast not necessary
- High spatial resolution (<0.5mm)
- Rapid temporal resolution (<50ms)
- Can image through Ca++
- Complementary data on LV fxn, viability, ischemia

Limitations:
- Longer scan time
- PPMs/ICDs, stents
- Technically more complicated
- Few large multi-center clinical trials
Where is Coronary MR?

**Yes**
- Coronary Anomalies
- Coronary Aneurysms
- Bypass Graft Patency
- Ischemic vs. Non-ischemic CMP
- Whole-Heart CAD

**Next**
- Coronary Wall/Plaque
- Coronary Vasodilation
- Coronary Inflammation
- Plaque Hemorrhage/Thrombus
Coronary Anomalies


- CMR: 100% accuracy (N=37)
  - 16 interarterial anomalies: 10 missed by Cath
  - 5 misclassified by Cath as interarterial

Courtesy: A. Gharib, M. Stuber, R. Pettigrew
Coronary Aneurysms


Ischemic vs. Non-Ischemic CMP

Multi-center Coronary MRA Trial

- Proximal CAD (N = 109)
- LM/3VD: Sens - 100%, Spec - 85%


Test Characteristics for the Detection of CAD Using cMRI and DE-MR

<table>
<thead>
<tr>
<th></th>
<th>cMRI N = 17</th>
<th>DE-MR N = 21</th>
<th>Combined Assessment N = 21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>100%</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>Specificity</td>
<td>100%</td>
<td>92%</td>
<td>92%</td>
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<tr>
<td>Positive predictive value</td>
<td>100%</td>
<td>86%</td>
<td>89%</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>100%</td>
<td>86%</td>
<td>100%</td>
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</table>

Hauser TH, et al. *SCMR* 2005
Whole-Heart CAD

Courtesy, O. Weber, UCSF

### Whole-Heart CAD

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>Accuracy (%)</th>
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</thead>
<tbody>
<tr>
<td>Per patient</td>
<td>113</td>
<td>82 (69–91)</td>
<td>90 (79–96)</td>
<td>88 (74–95)</td>
<td>86 (75–93)</td>
<td>87 (79–92)</td>
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<tr>
<td>Per vessel</td>
<td>452</td>
<td>78 (66–86)</td>
<td>96 (93–97)</td>
<td>79 (67–87)</td>
<td>95 (93–97)</td>
<td>93 (90–95)</td>
</tr>
<tr>
<td>RCA</td>
<td>113</td>
<td>85 (65–95)</td>
<td>95 (88–98)</td>
<td>85 (65–95)</td>
<td>95 (88–98)</td>
<td>93 (86–97)</td>
</tr>
<tr>
<td>LM</td>
<td>113</td>
<td>NA</td>
<td>98 (93–100)</td>
<td>NA</td>
<td>100 (96–100)</td>
<td>98 (93–100)</td>
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<tr>
<td>LAD</td>
<td>113</td>
<td>77 (56–90)</td>
<td>95 (88–99)</td>
<td>83 (62–95)</td>
<td>93 (85–97)</td>
<td>91 (84–95)</td>
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<td>LCX</td>
<td>113</td>
<td>70 (47–86)</td>
<td>93 (86–97)</td>
<td>73 (50–88)</td>
<td>92 (84–97)</td>
<td>89 (81–94)</td>
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<tr>
<td>Per segment</td>
<td>1,000</td>
<td>78 (68–85)</td>
<td>96 (95–97)</td>
<td>69 (60–77)</td>
<td>98 (96–98)</td>
<td>94 (93–96)</td>
</tr>
</tbody>
</table>
CTA Multi-Center Trial Results – ACCURACY

N=229, no exclusions
Patient with heavy coronary calcification (71M)
Coronary CTA vs. MRA

64-slice MDCT

Whole heart coronary MRA

Ichikawa Y, Sakuma H, Mie, Japan
MRA vs. CTA for Ca++ Lesions

CTA
Sens/Spec/AUC - 75%, 48%, 0.65

MRA
Sens/Spec/AUC - 81%, 75%, 0.83

Coronary MRA at 3T


- 3T vs. 1.5T: SNR ↑41%

0.34x0.35x1.5mm (acquired)
0.26x0.26x0.75mm (recon)
Breath-Hold Whole-Heart Coronaries

2D Spiral @ 3T
0.8x0.8x1.6mm

Santos JM, et al. *MRM* 2005

32-Channel Coil

Parallel Imaging:
8-fold acceleration

Coronary Plaque/Wall


RCA wall

Thickened walls

CAC < 100

CAC ≥ 100

* *p = 0.02
Newer Applications

Vasodilation

Pre-NTG

Post-NTG

Terashima M, et al. JACC 2005

Inflammation

STIR

DE-MRI

McMahon, C. J. et al. Circulation 2005

Botnar R, et al

Coronary Enhancement

A)

RCA

MRA

B)

MDCT

CE-IR

thrombus or hemorrhage?

Yeon SB, Sabir A, Clouse M, et al. SCMR 2005

0.2mmol/kg

native

thrombus or hemorrhage?
Conclusions

• Coronary MRA is well established for multiple important clinical applications.
• For whole-heart CAD imaging, initial studies are promising, but larger multi-center trials needed.
• MRA appears better than CTA for calcified lesions.
• Coronary MR can go beyond the lumen to assess plaque, vasodilation, thrombus, and inflammation.
• Wouldn’t you rather have no IV, contrast, radiation?
Acknowledgements

Stanford University

Cardiovascular Medicine
Masahiro Terashima, MD, PhD
Phillip C. Yang, MD
Patricia Nguyen, MD
Brian K. Courtney, MD
Shoichi Ehara, MD, PhD
Miwako Tsukiji, MD
Peter Fitzgerald, MD, PhD
Philip Tsao, PhD

Electrical Engineering
Dwight Nishimura, PhD
John Pauly, PhD
Steve Conolly, PhD
Greig Scott, PhD
Charles Cunningham, PhD
Juan Santos, PhD

Molecular Imaging Program
Francis Blankenberg, MD
Chris Contag, PhD
Samira Guccione, PhD
Joseph Wu, MD, PhD
Sam Gambhir, MD, PhD

Radiology
Geoffrey Rubin, MD
Robert Herfkens, MD

Montana State
Trevor Douglas, PhD
Mark Young, PhD

University of Washington
Chun Yuan, PhD
Vasily Yarnykh, PhD
Intravascular Contrast Agent

T2 prep

B22956

Courtesy E. Nagel and I. Paetsch. Cardiology, German Heart Institute, Berlin.
Contrast-Enhanced Whole-Heart @ 3T

X. Bi, J.C. Carr, D. Li  *MRM* 2007
Self-Navigated Whole-Heart MR

<table>
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<tr>
<th>Navigator Gated (5mm)</th>
<th>Self-Navigated</th>
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<tr>
<td>Localizer scans</td>
<td>2</td>
</tr>
<tr>
<td>Scan time</td>
<td>16 min</td>
</tr>
<tr>
<td>Efficiency</td>
<td>50%</td>
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<tr>
<td>Localizer scans</td>
<td>1</td>
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<tr>
<td>Scan time</td>
<td>8 min</td>
</tr>
<tr>
<td>Efficiency</td>
<td>100%</td>
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*Stehning et al.: MRM 2005*
2D Navigator Whole-Heart 3D Cones

2D Navigator Acquisition

- Cardiac Trigger
- Systolic Rest Period
- Diastolic Rest Period
- Cardiac Trigger

3D Coronary Acquisition

P. Gurney ISMRM 2007

1.1 x 1.1 x 1.5 mm³ ~10 min scan time
Contrast Enhanced Coronary MRI

“Inflammation”

Patient with ACS

9 days post AMI

3 month post AMI

Ibrahim T, Botnar RM. ISMRM 2007