Coronary MRI: State-of-the-Art

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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?

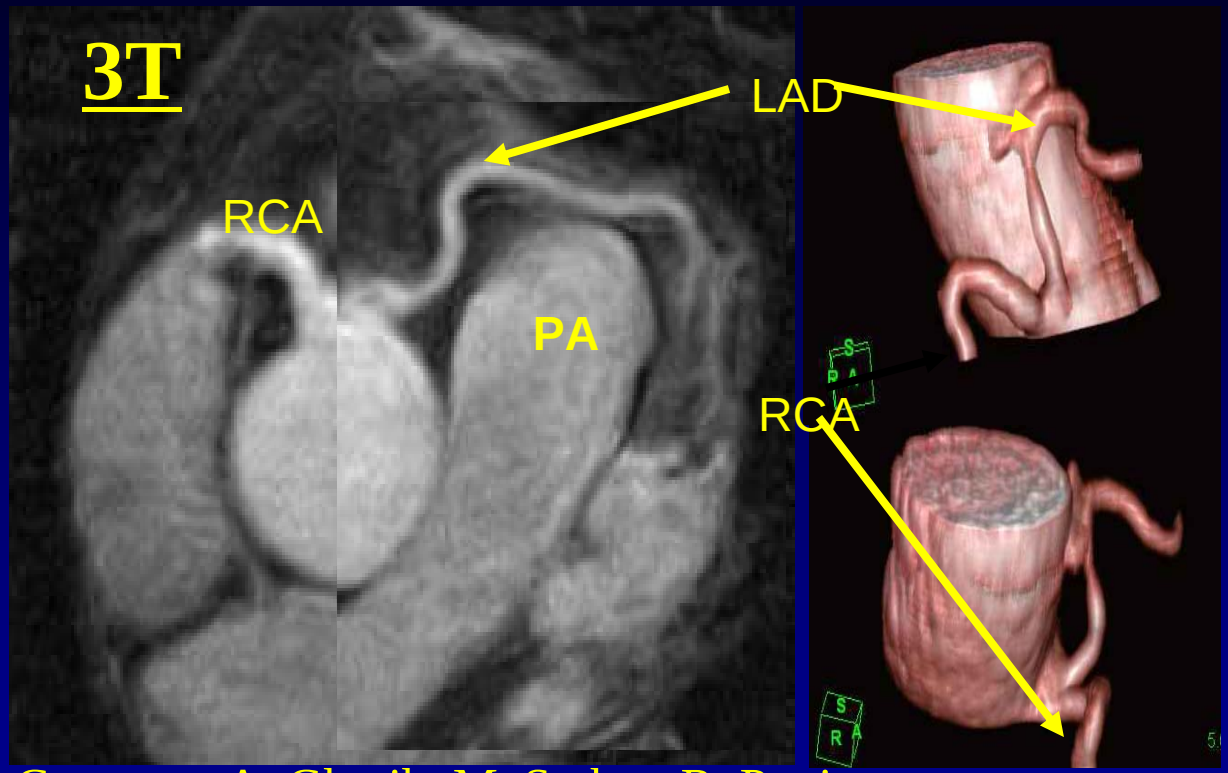
Yes

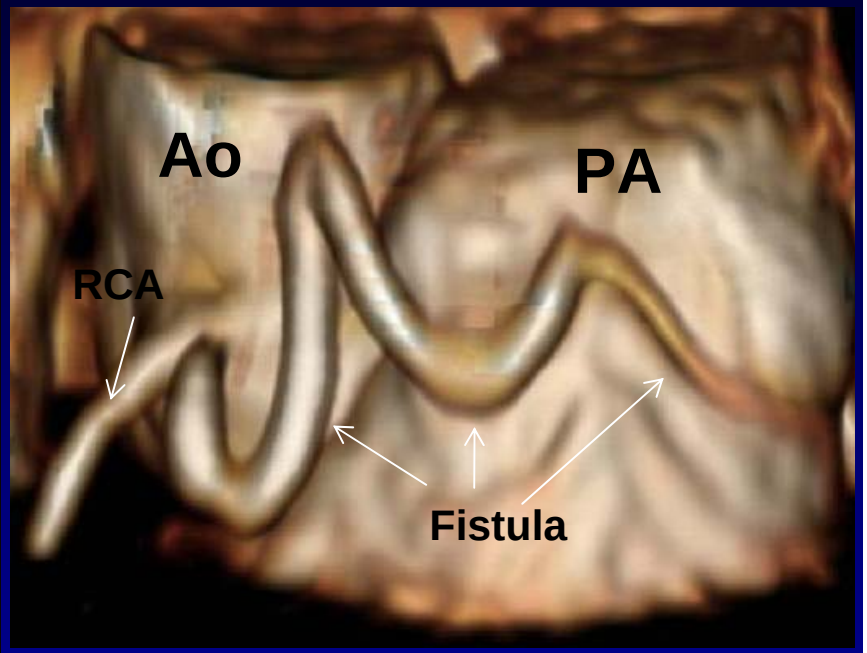
Coronary Anomalies
Coronary Aneurysms
Bypass Graft Patency
Ischemic vs. Non-ischemic CMP
Whole-Heart CAD

Next

Coronary Wall/Plaque
Coronary Vasodilation
Coronary Inflammation
Plaque Hemorrhage/Thrombus

Coronary Anomalies



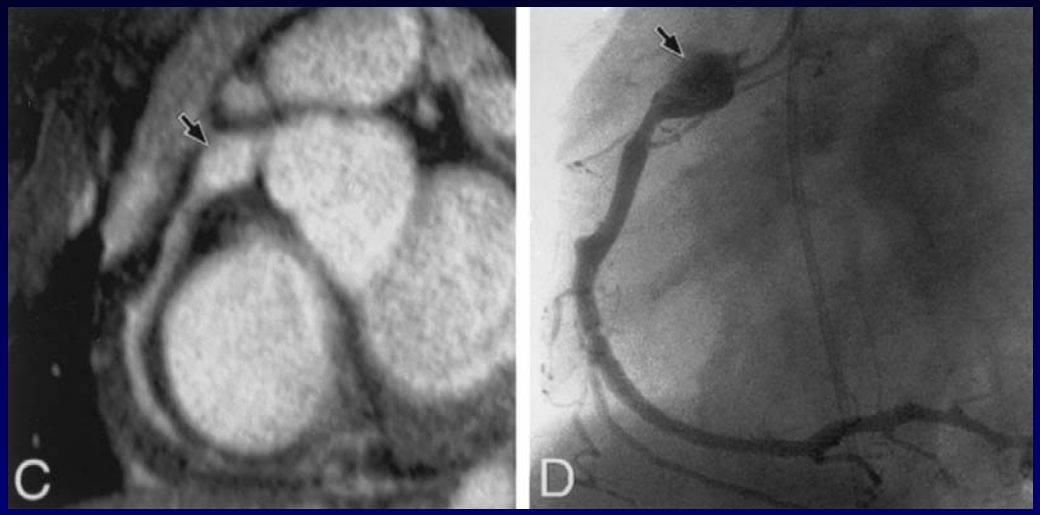


Courtesy: A. Gharib, M. Stuber, R. Pettigrew

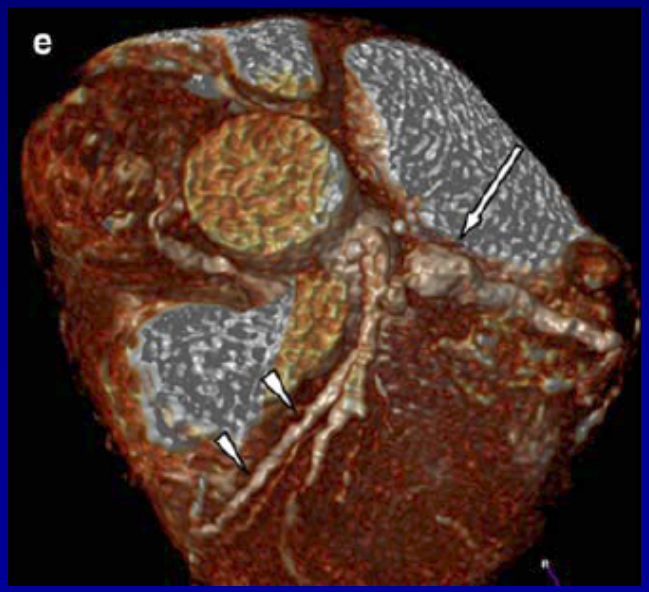
SCMR 2007: Rathi V, et al.

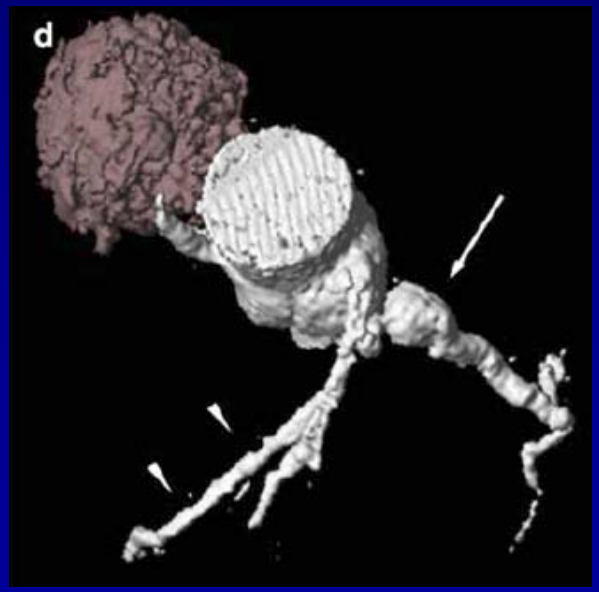
- **CMR: 100% accuracy (N=37)**
  - **16 interarterial anomalies: 10 missed by Cath**
  - **5 misclassified by Cath as interarterial**

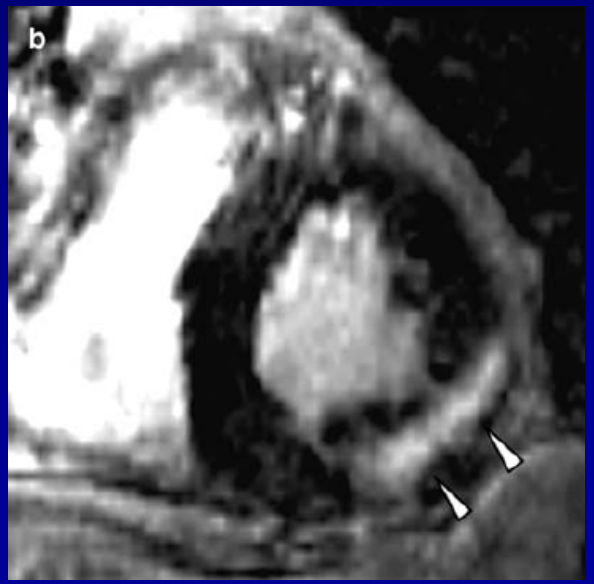
Coronary Aneurysms



Greil, G. F. et al. *Circulation* 2002







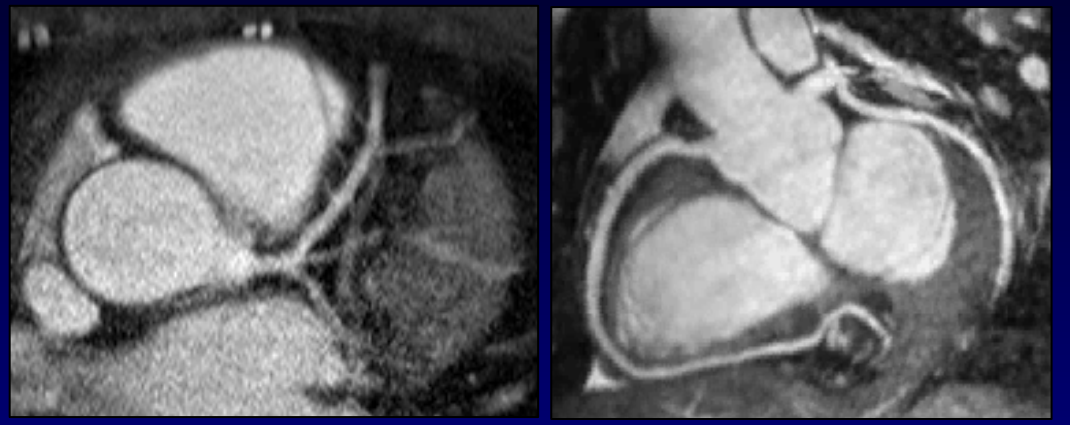
Gomaa O, et al. *Int J Cardiovasc Imaging* 2006

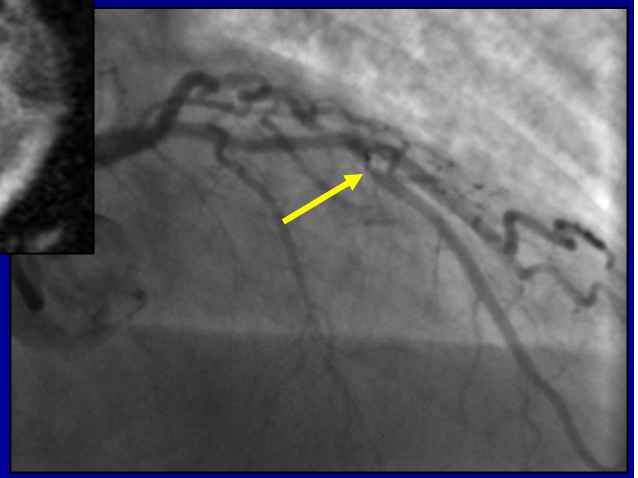
Ischemic vs. Non-Ischemic CMP

Multi-center Coronary MRA Trial

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

Kim WY, et al. *NEJM* 2001



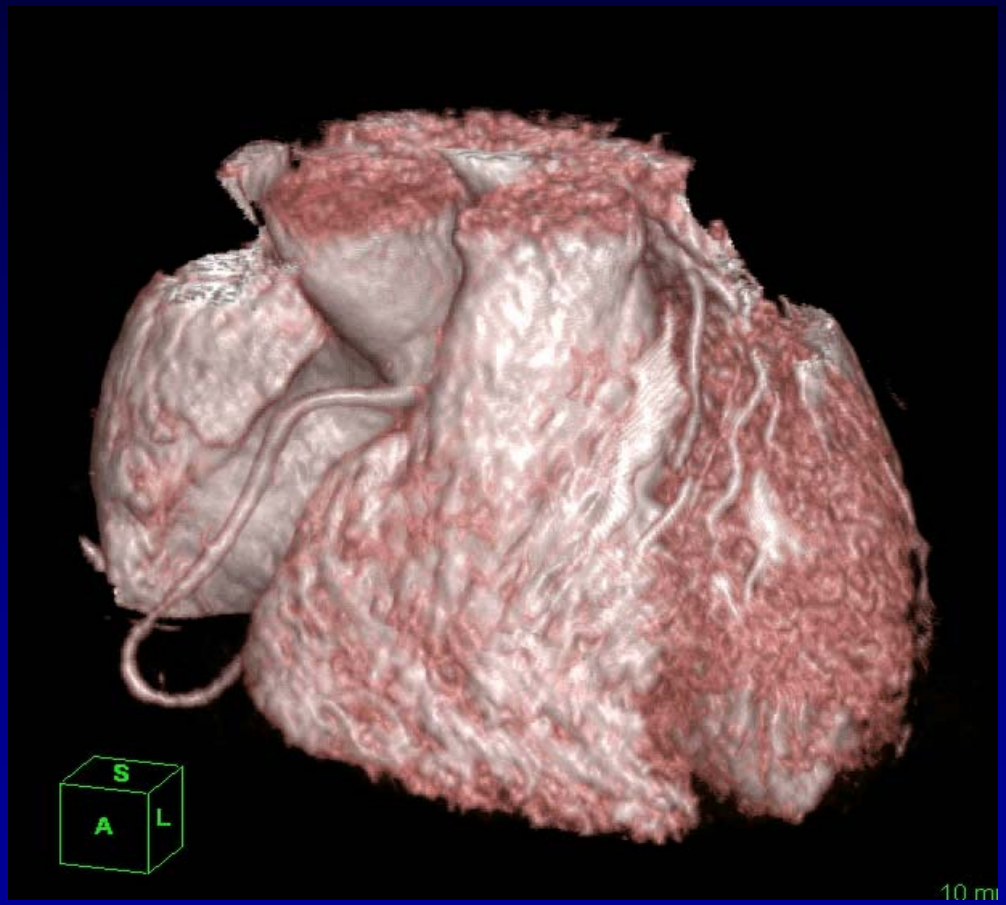


Test Characteristics for the Detection of CAD Using cMRI and DE-MR

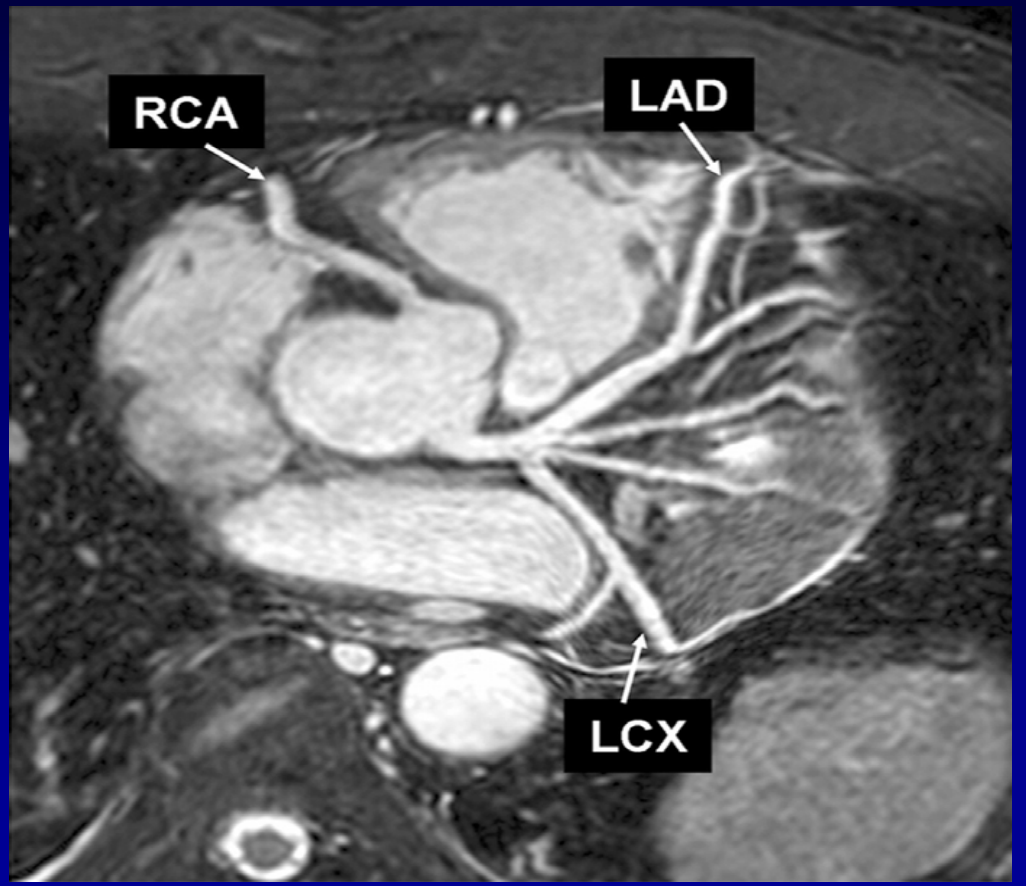
	cMRI N = 17	DE-MR N = 21	Combined Assessment N = 21
Sensitivity	100%	75%	100%
Specificity	100%	92%	92%
Positive predictive value	100%	86%	89%
Negative predictive value	100%	86%	100%

Hauser TH, et al. *SCMR* 2005

Whole-Heart CAD

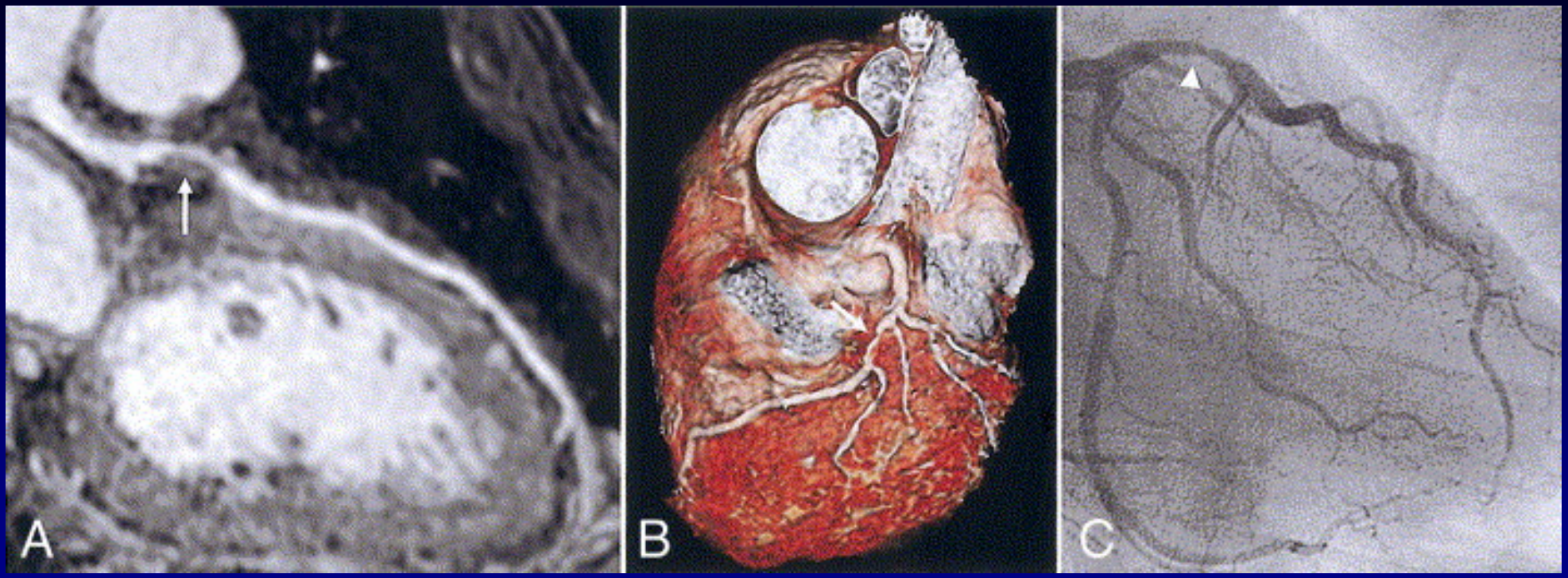


Courtesy, O. Weber, UCSF



Sakuma, H. et al. Radiology 2005;237:316-321

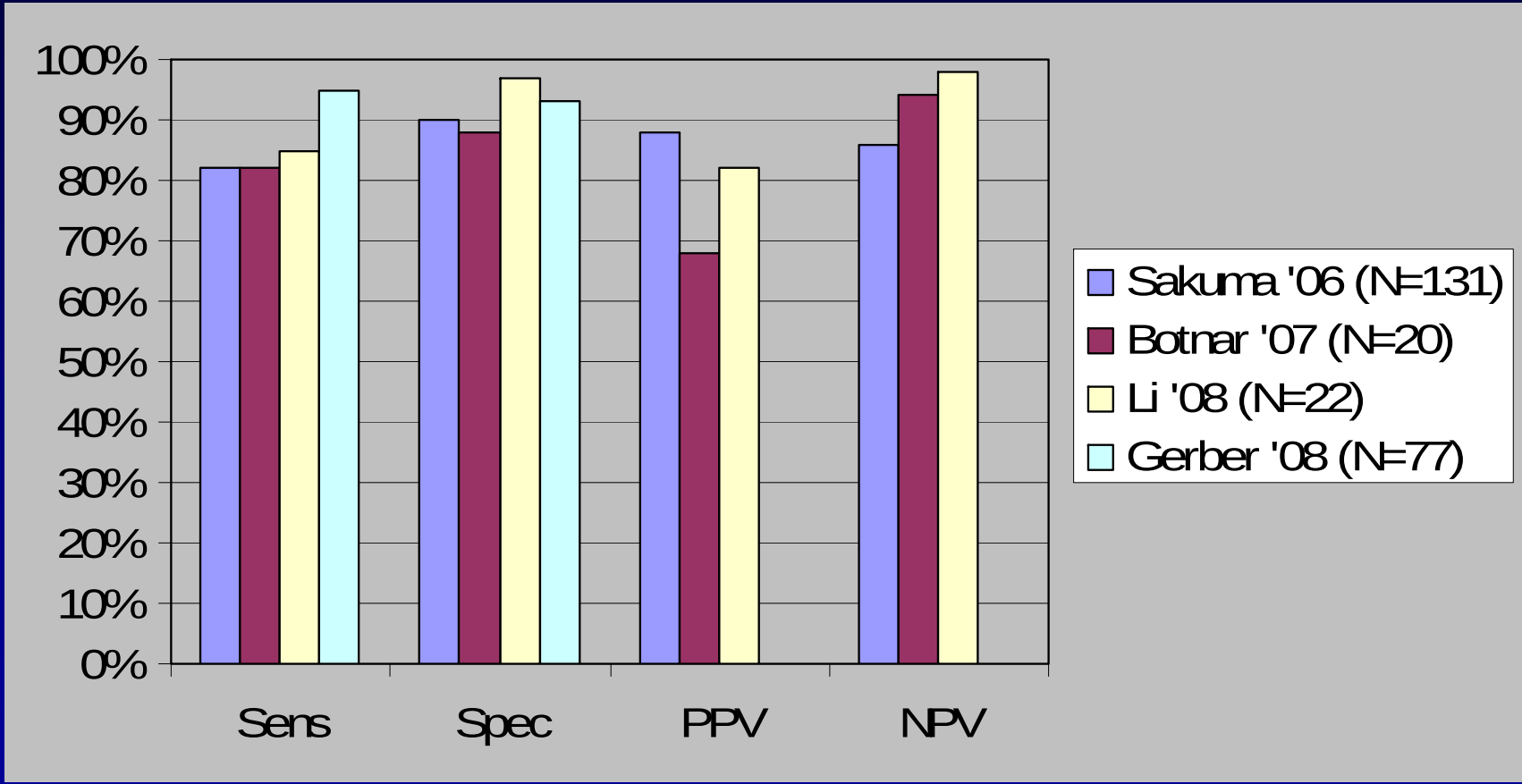
Whole-Heart CAD



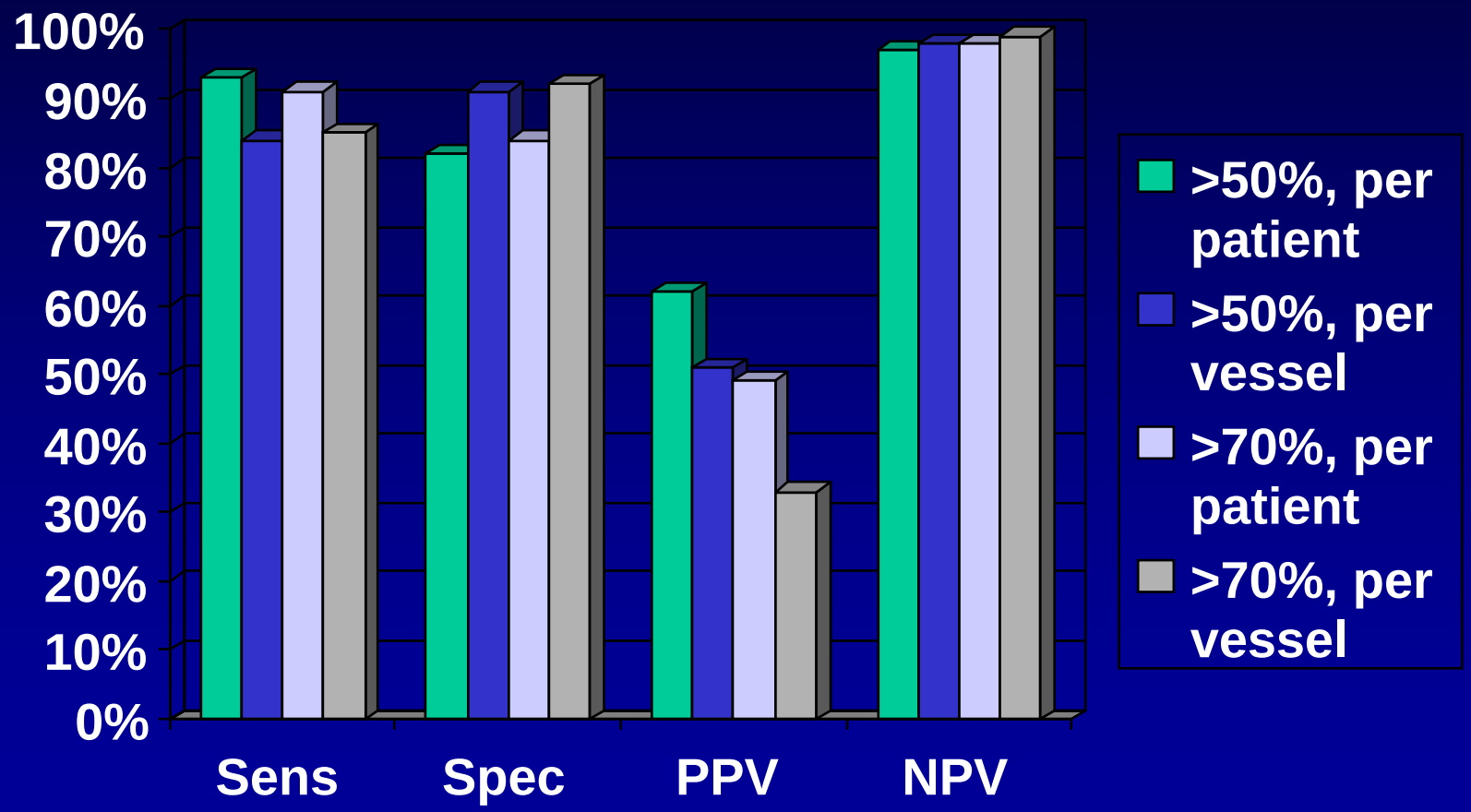
	n	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Per patient	113	82 (69–91)	90 (79–96)	88 (74–95)	86 (75–93)	87 (79–92)
Per vessel	452	78 (66–86)	96 (93–97)	79 (67–87)	95 (93–97)	93 (90–95)
RCA	113	85 (65–95)	95 (88–98)	85 (65–95)	95 (88–98)	93 (86–97)
LM	113	NA	98 (93–100)	NA	100 (96–100)	98 (93–100)
LAD	113	77 (56–90)	95 (88–99)	83 (62–95)	93 (85–97)	91 (84–95)
LCX	113	70 (47–86)	93 (86–97)	73 (50–88)	92 (84–97)	89 (81–94)
Per segment	1,000	78 (68–85)	96 (95–97)	69 (60–77)	98 (96–98)	94 (93–96)

Sakuma, H. et al. JACC 2006

Coronary MRA vs. Cath - Recent Data

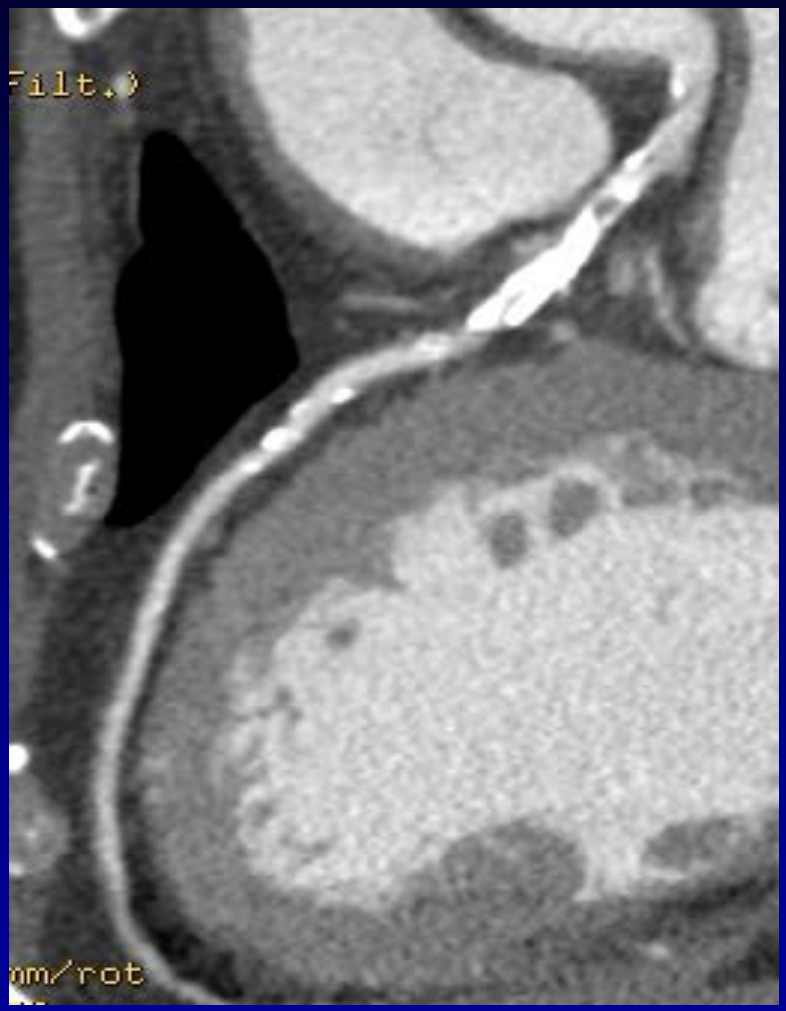


CTA Multi-Center Trial Results – ACCURACY



N=229, no exclusions

Patient with heavy coronary calcification (71M)
Coronary CTA vs. MRA

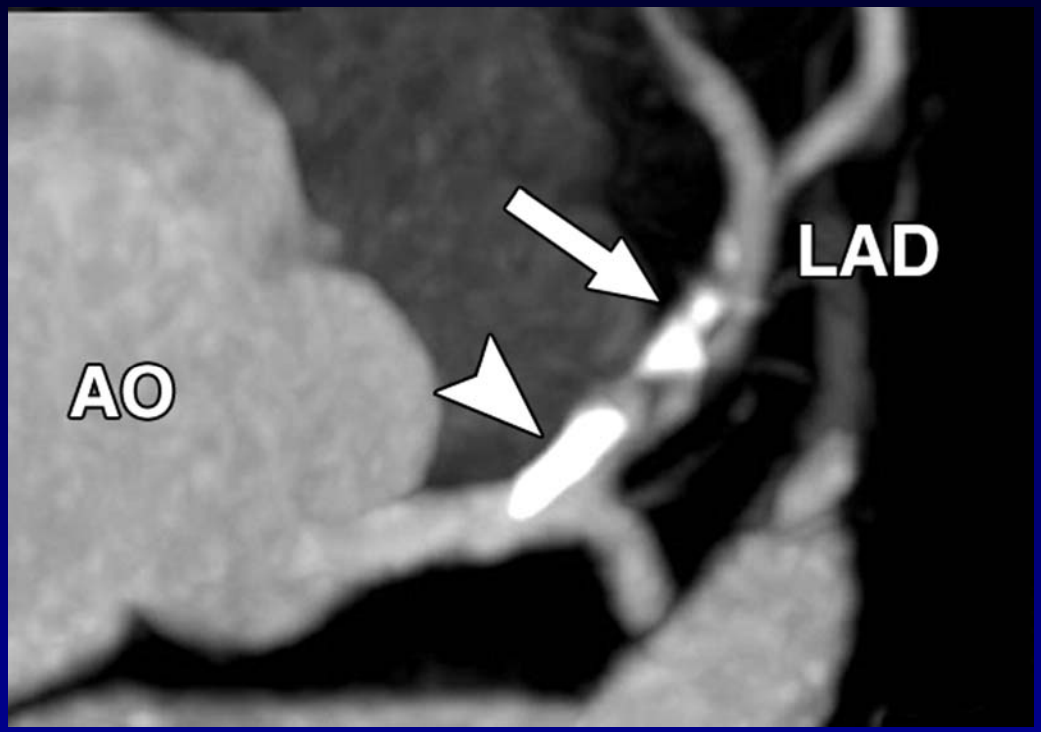


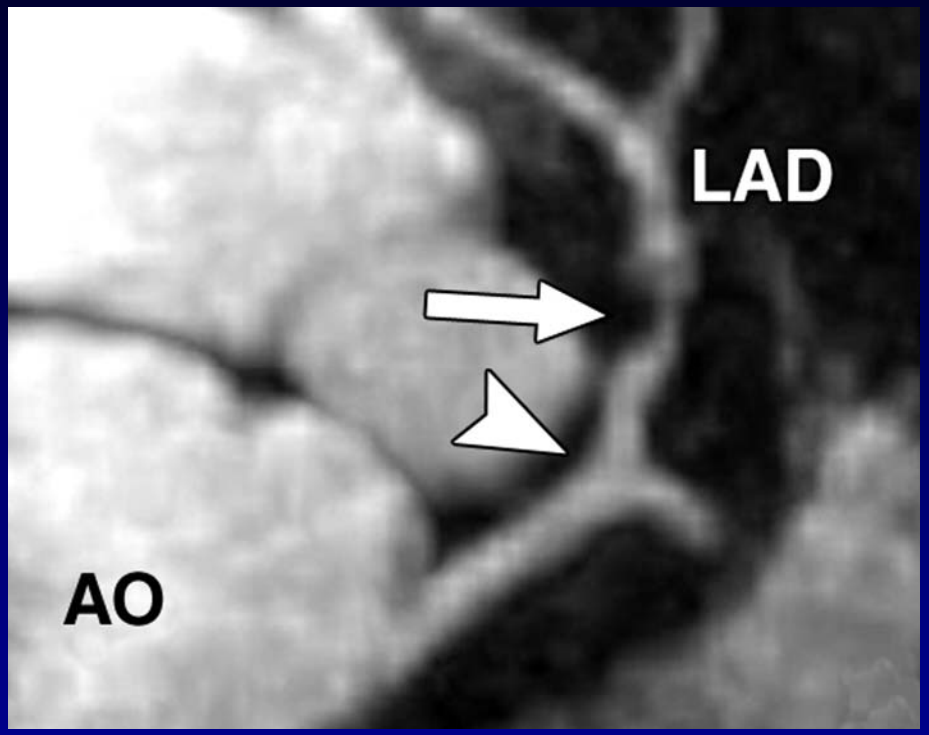
64-slice MDCT

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

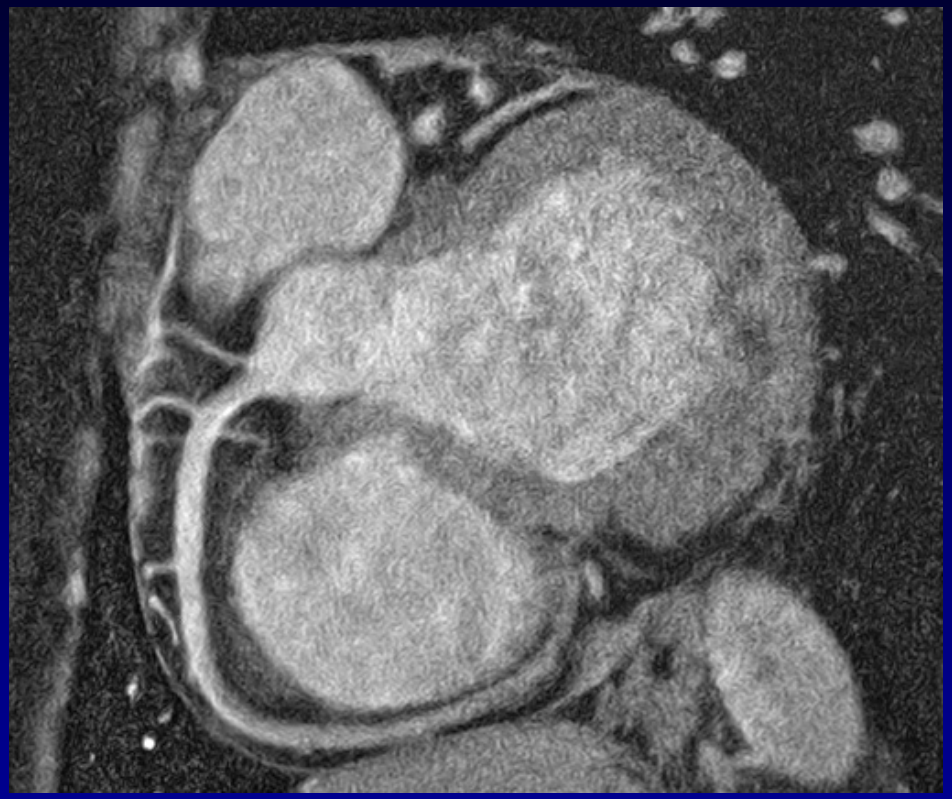
Sens/Spec/AUC - 81%, 75%, 0.83

Liu, X. et al. Am. J. Roentgenol. 2007;189:1326-1332

Coronary MRA at 3T

Nayak K, et al. *MRM*. 2004

Yang P, et al. *JCMR* 2005
- 3T vs. 1.5T: SNR ↑41%

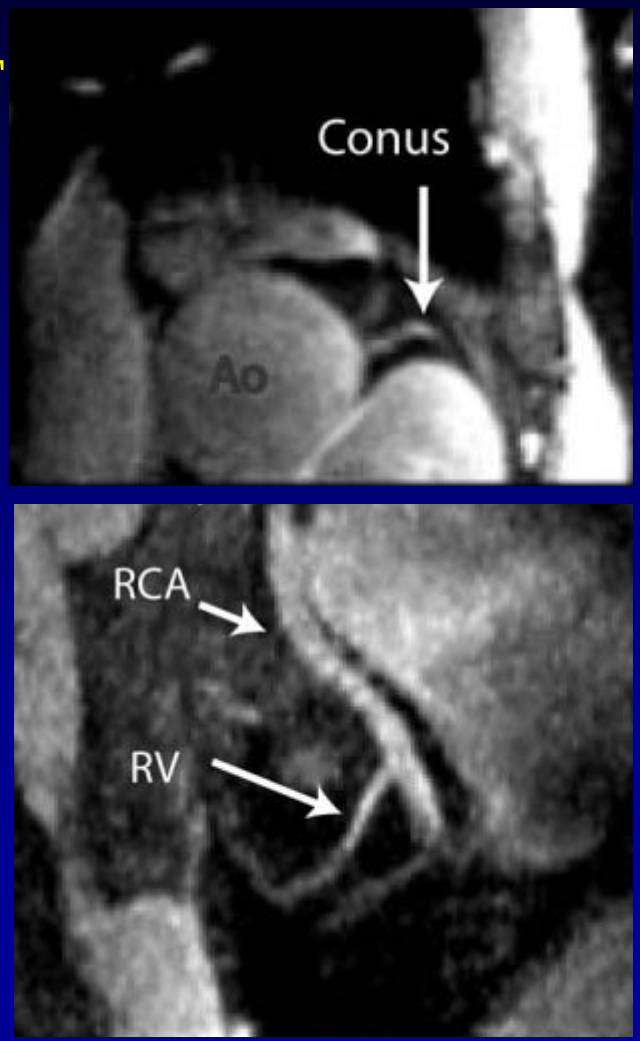


Ustun A, et al. *AJR*. 2007

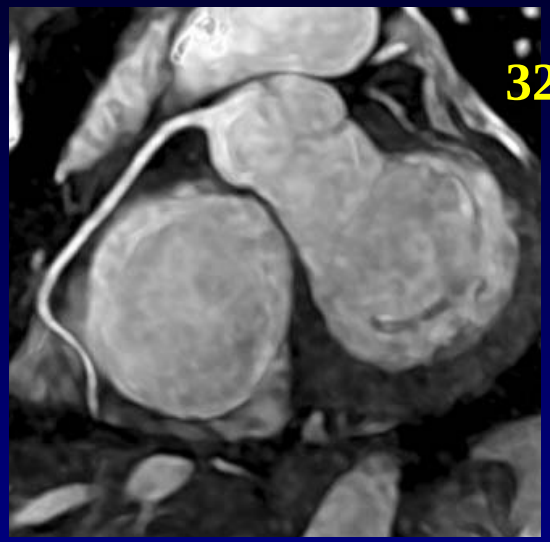
0.34x0.35x1.5mm (acquired)
0.26x0.26x0.75mm (recon)

Breath-Hold Whole-Heart Coronaries

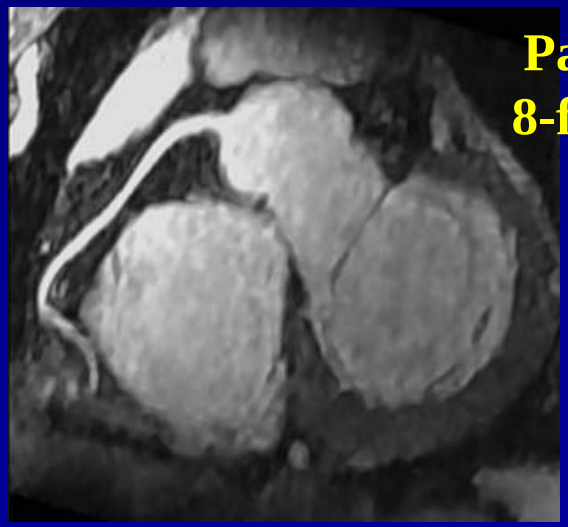
2D Spiral @ 3T
0.8x0.8x1.6mm



Santos JM, et al. *MRM* 2005



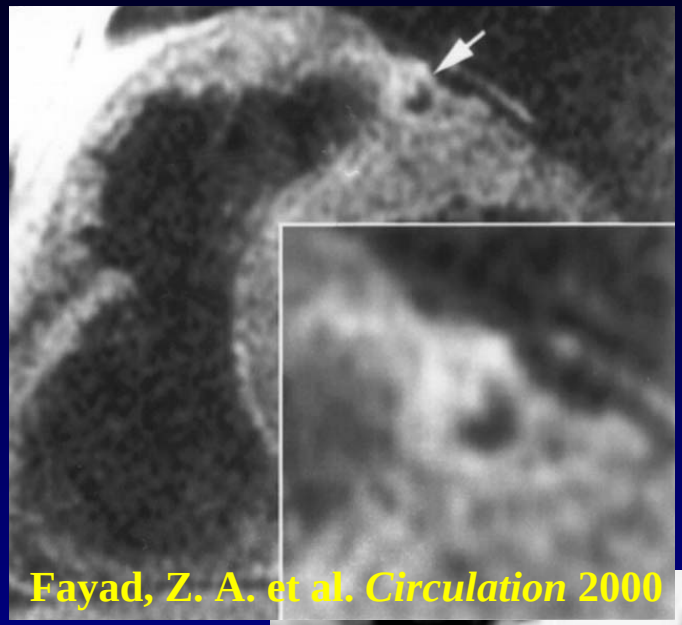
32-Channel Coil



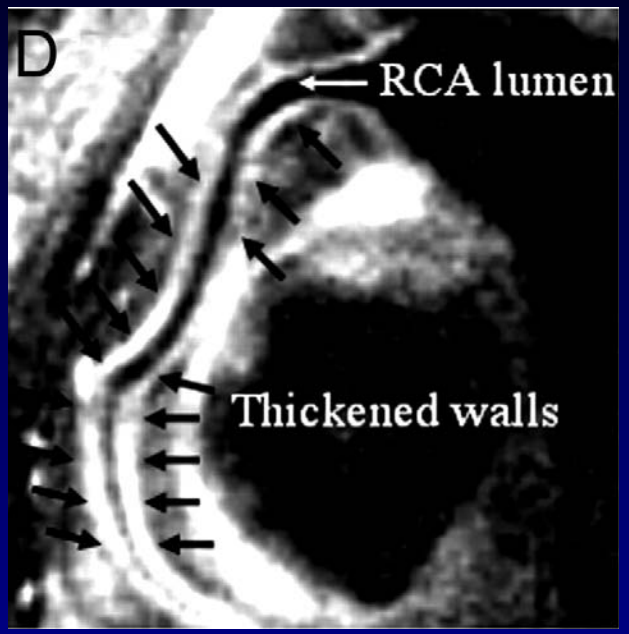
Parallel Imaging:
8-fold acceleration

Niendorf T, et al. *MRM* 2006

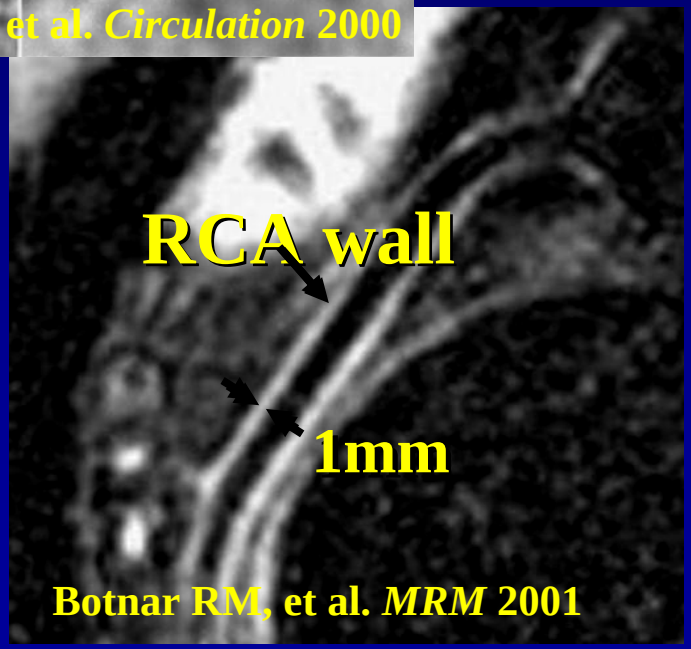
Coronary Plaque/Wall



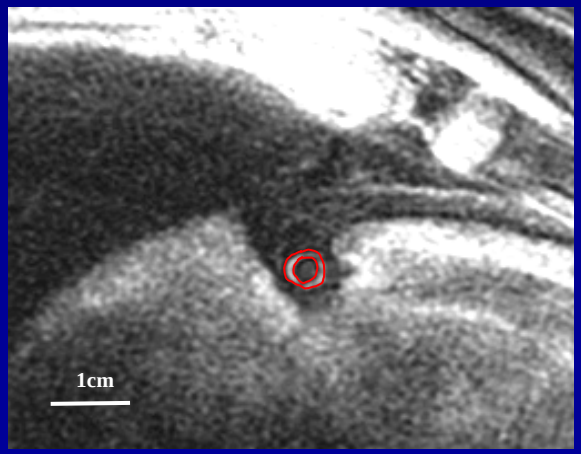
Fayad, Z. A. et al. *Circulation* 2000

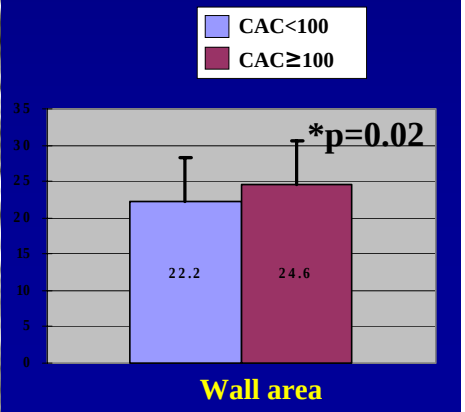


Kim, W. Y. et al. Circulation 2007



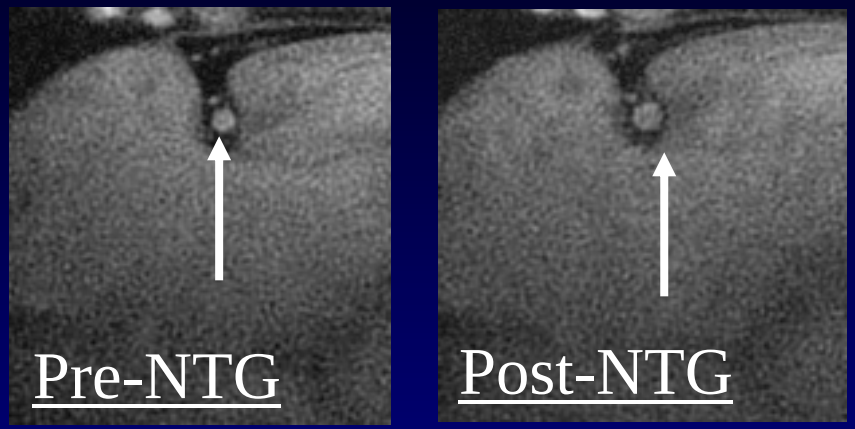
Botnar RM, et al. *MRM* 2001





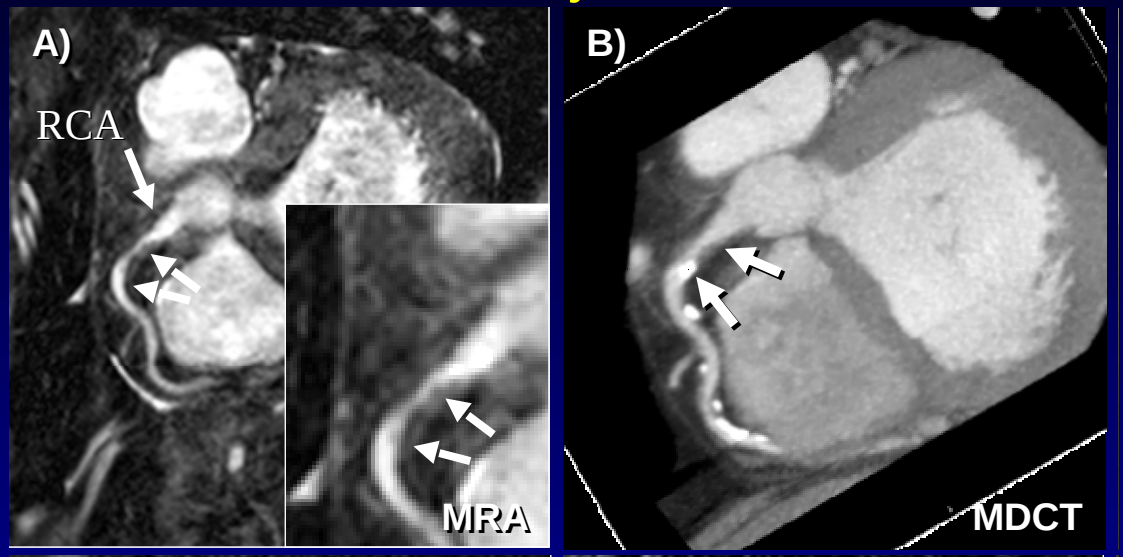
Newer Applications

Vasodilation

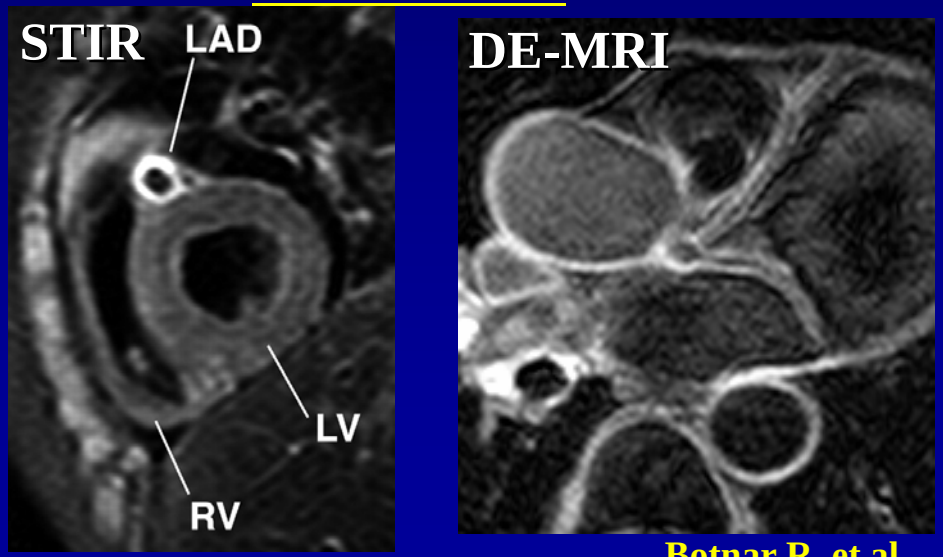


Terashima M, et al. *JACC* 2005

Coronary Enhancement

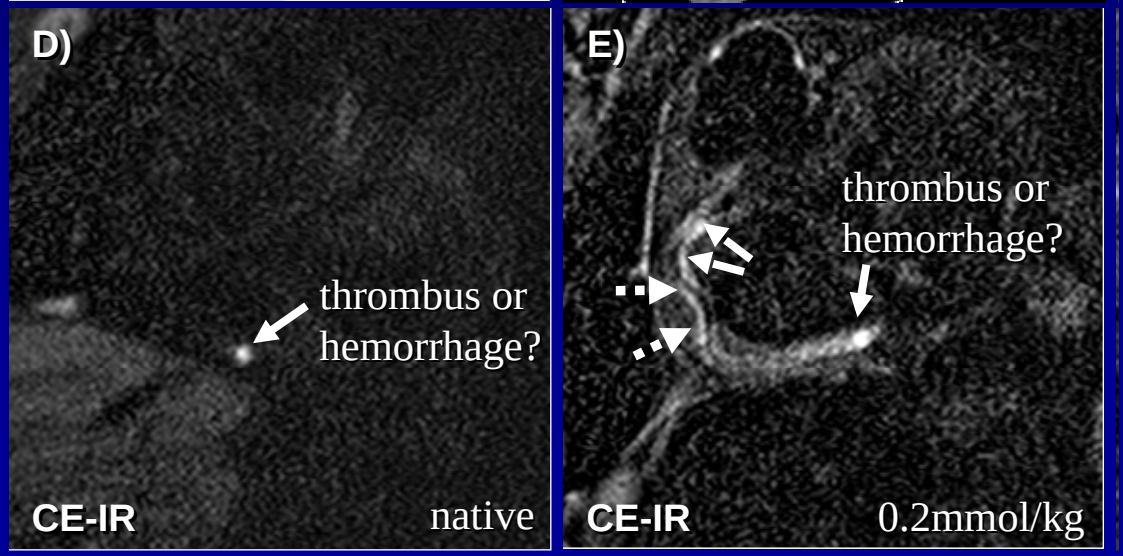


Inflammation



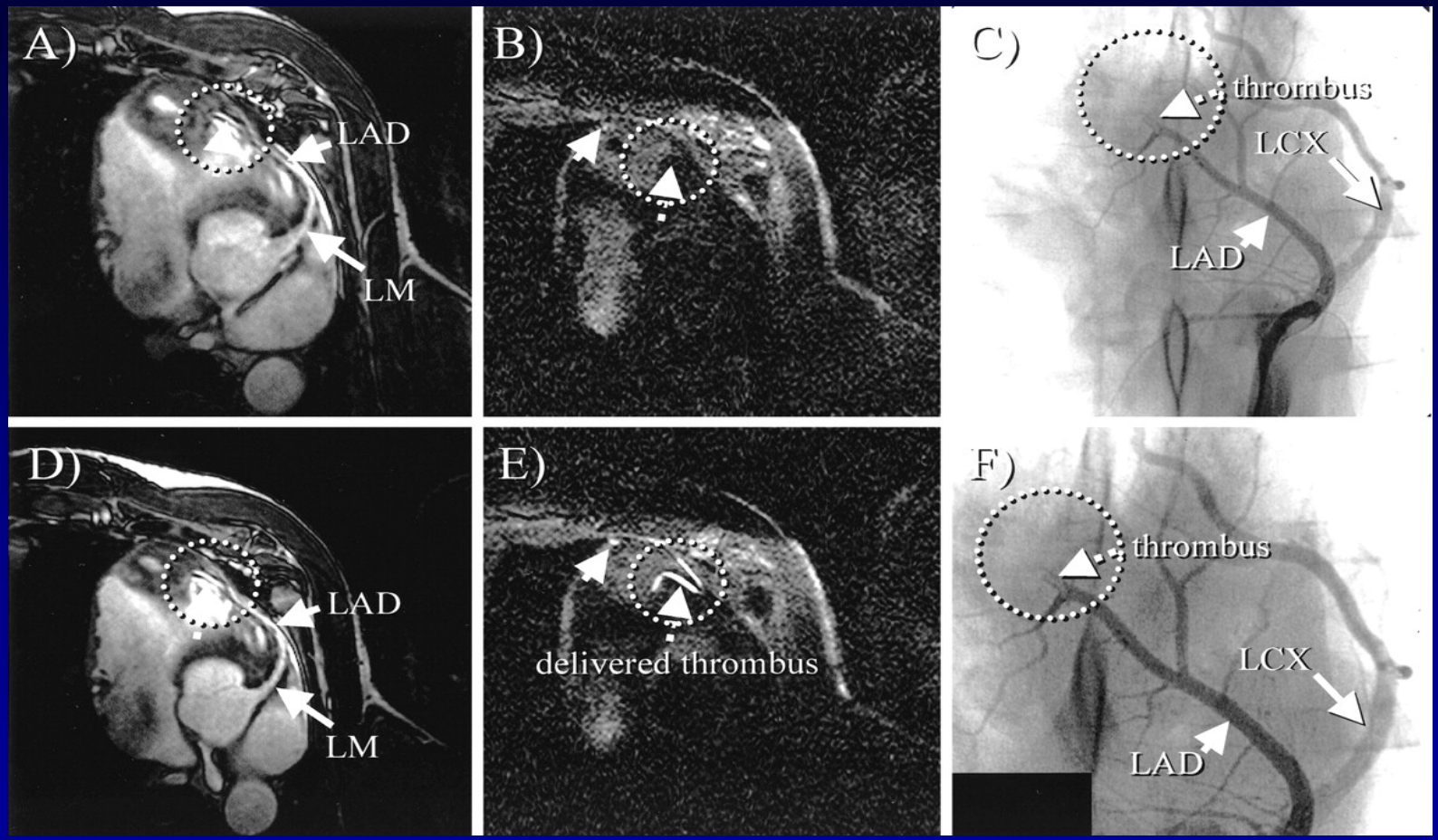
McMahon, C. J. et al. *Circulation* 2005

Botnar R, et al



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

Coronary Thrombus Imaging



Botnar RM, et al. *Circulation 2004*

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

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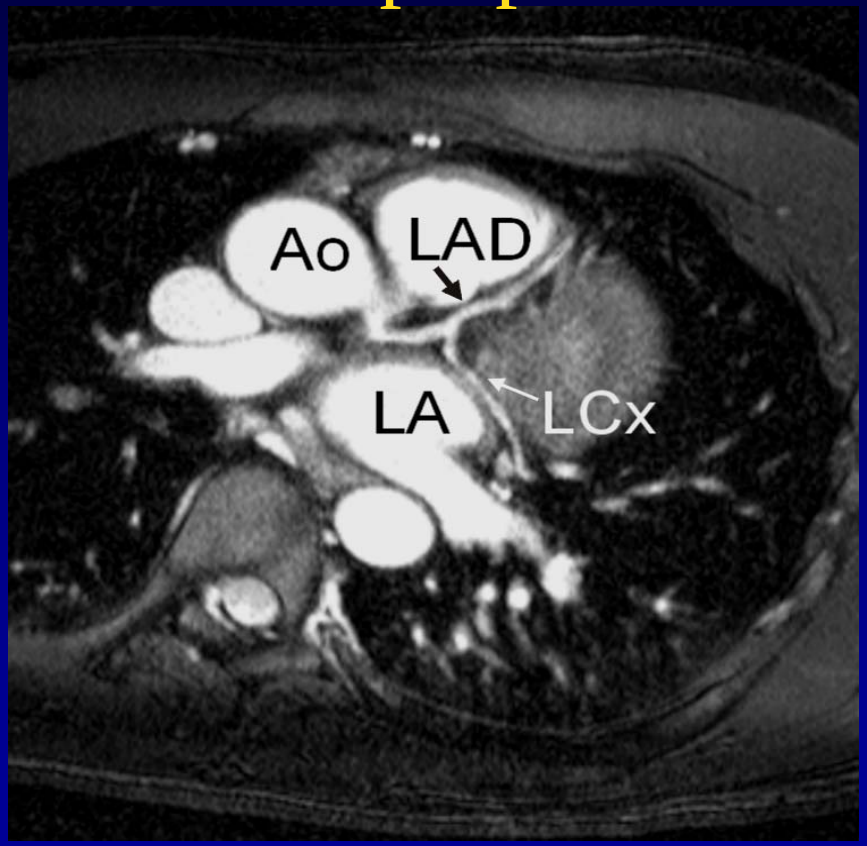
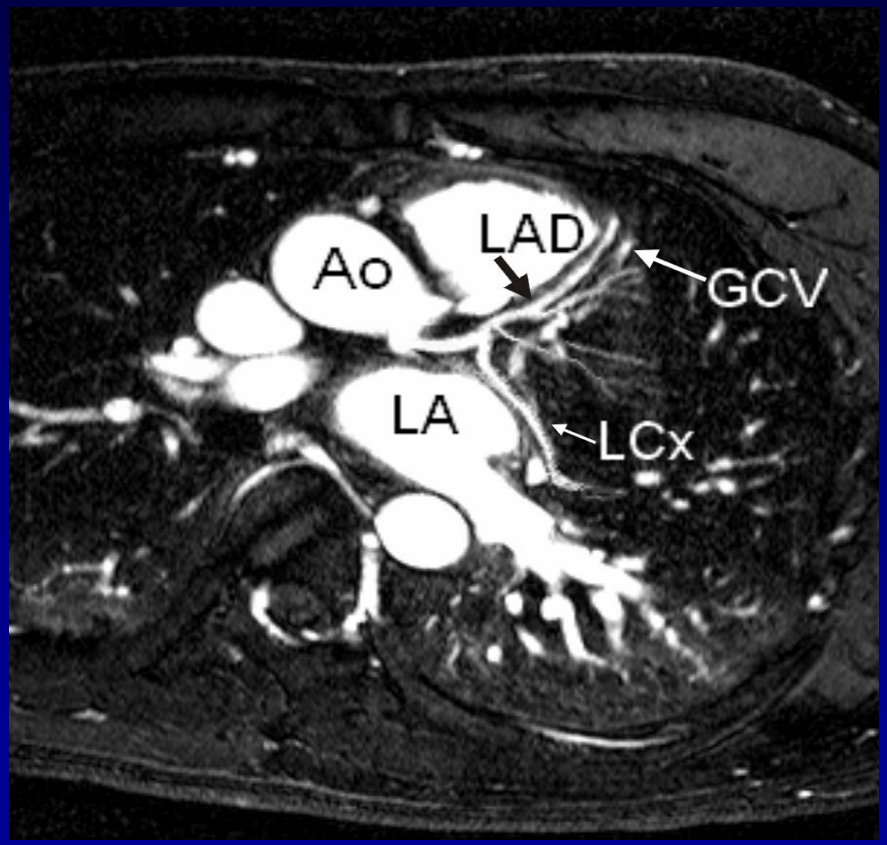
Intravascular Contrast Agent

T2 prep

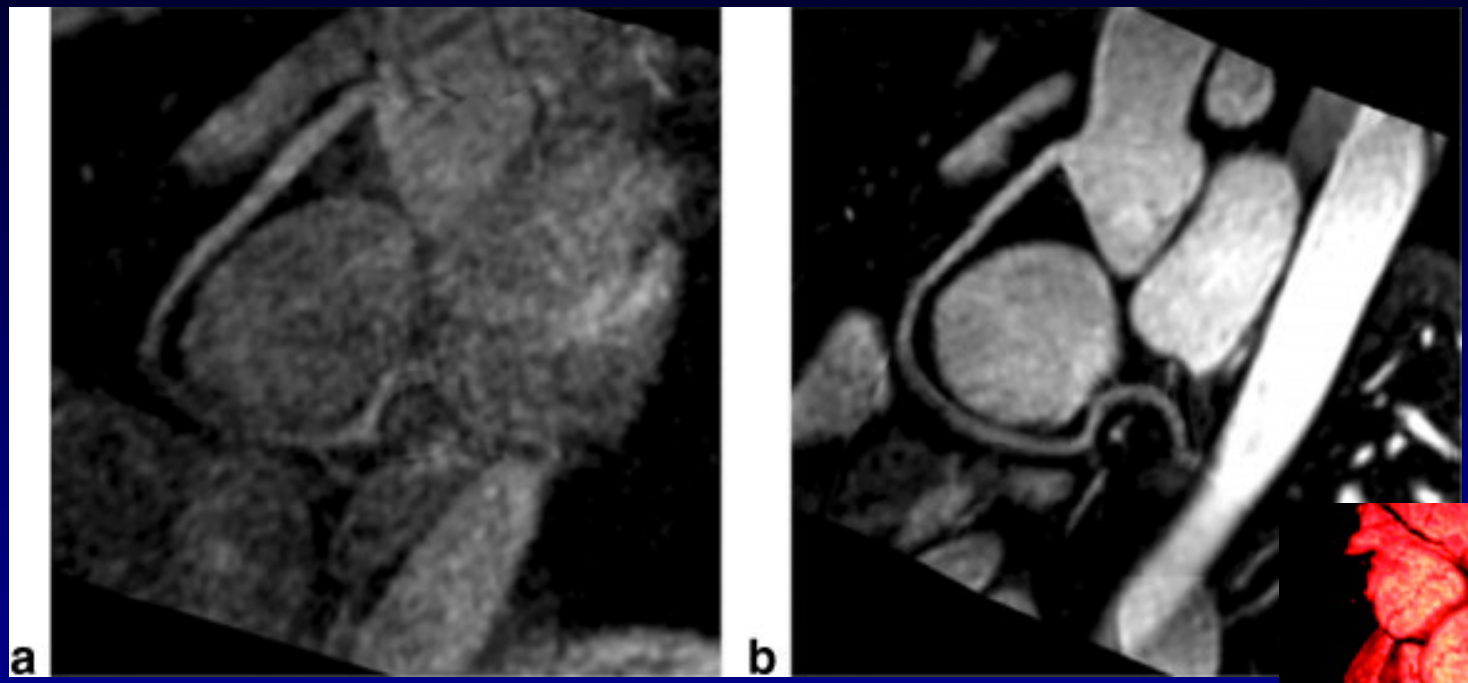


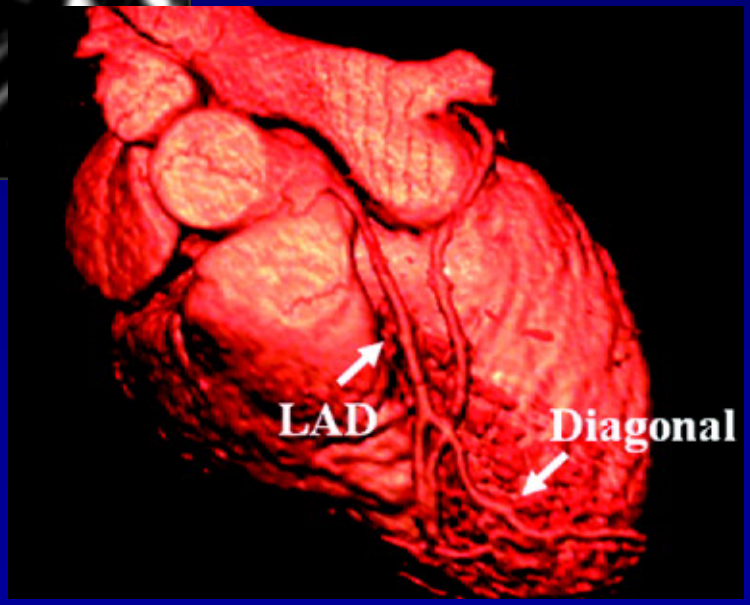
B22956



Courtesy E. Nagel and I. Paetsch. Cardiology, German Heart Institute, Berlin.

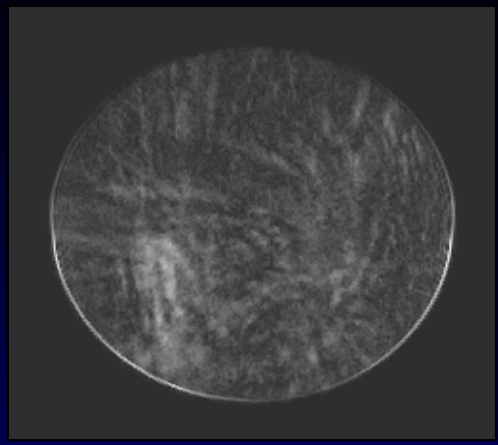
Contrast-Enhanced Whole-Heart @ 3T



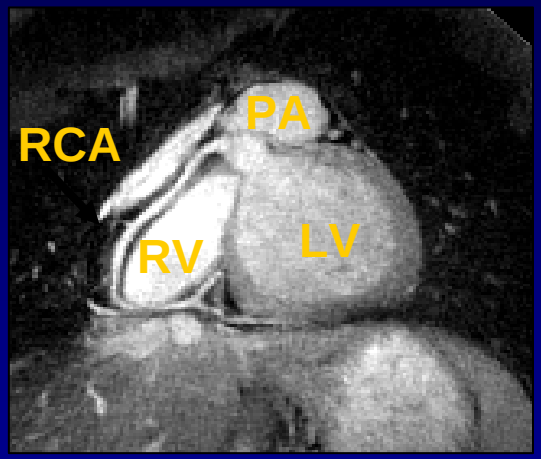


X. Bi, J.C. Carr, D. Li *MRM* 2007

Self-Navigated Whole-Heart MR

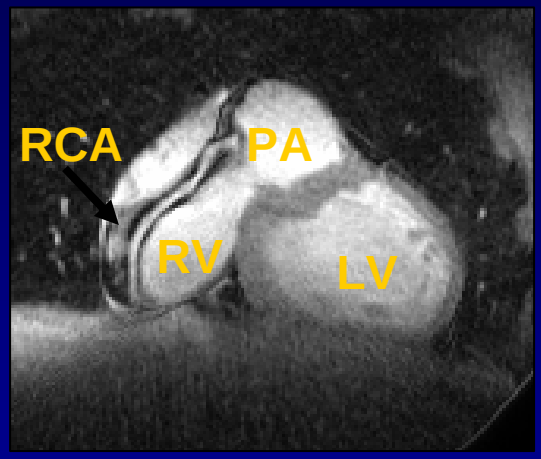


navigator-gated (5mm)



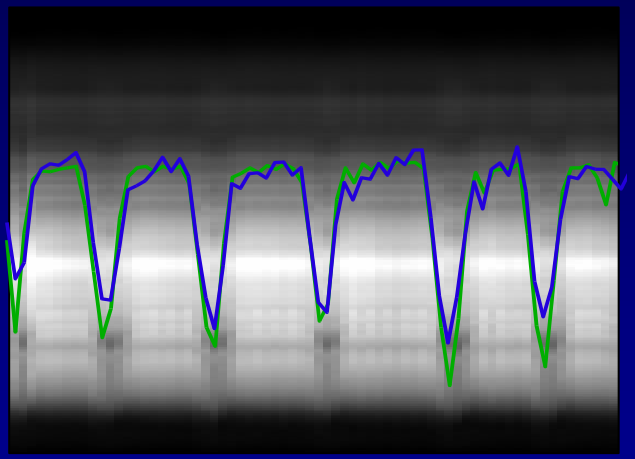
localizer scans	**2**
scan time	**16 min**
efficiency	**50%**

self-navigated



localizer scans	**1**
scan time	**8 min**
efficiency	**100%**

SI projections

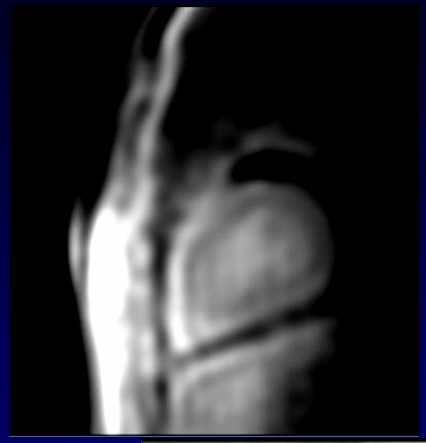


navigator position

center of mass

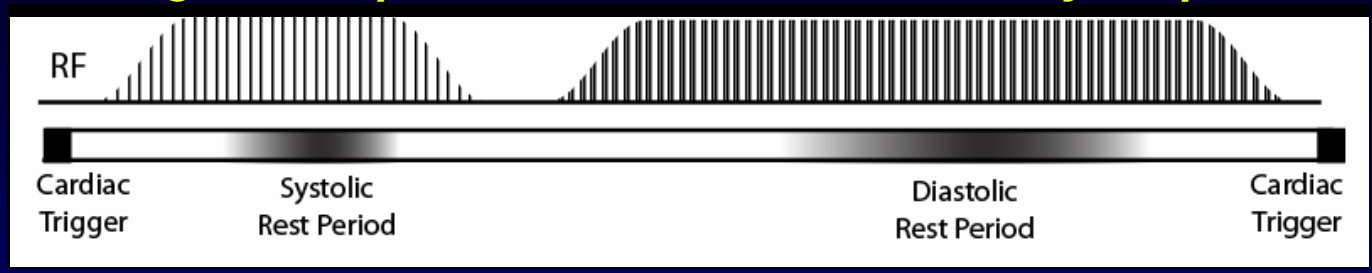
***Stehning et al.: MRM 2005**

2D Navigator Whole-Heart 3D Cones

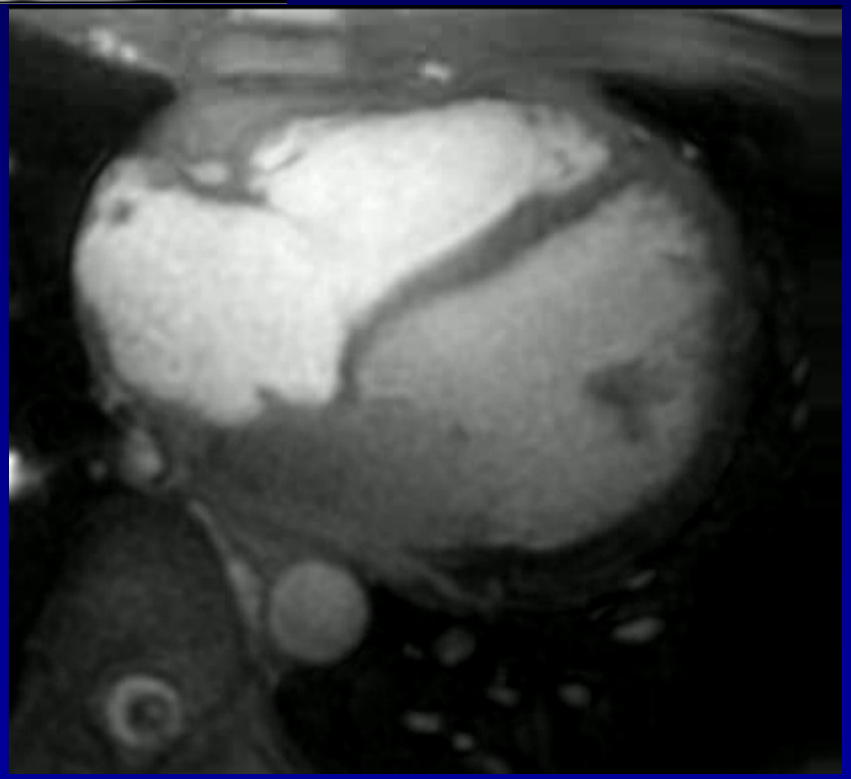


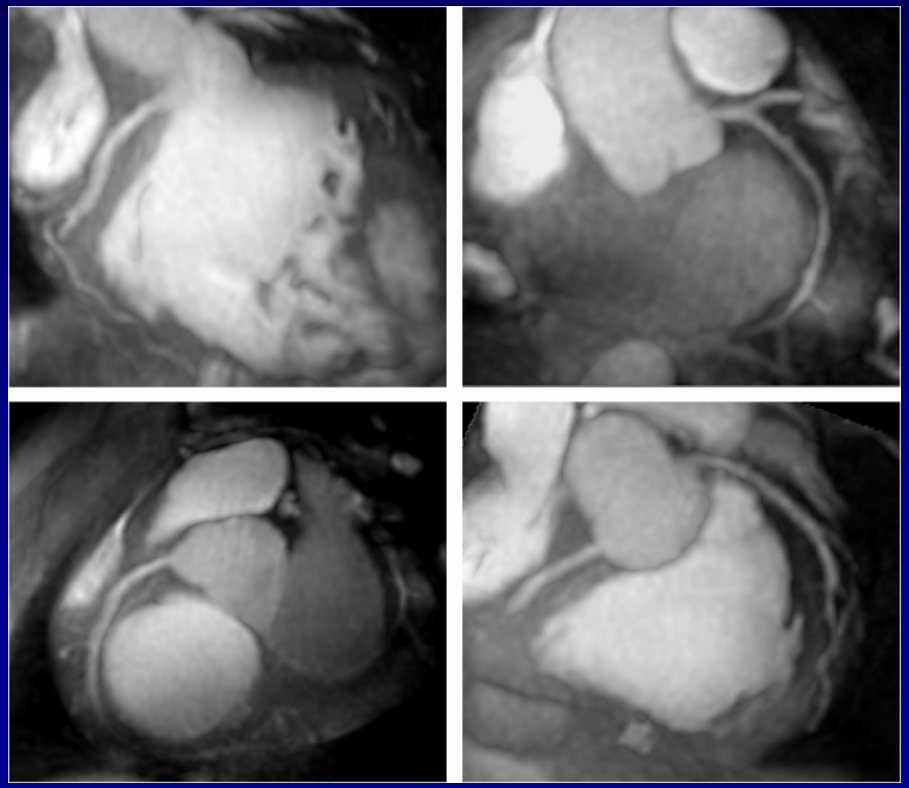
2D Navigator Acquisition

3D Coronary Acquisition



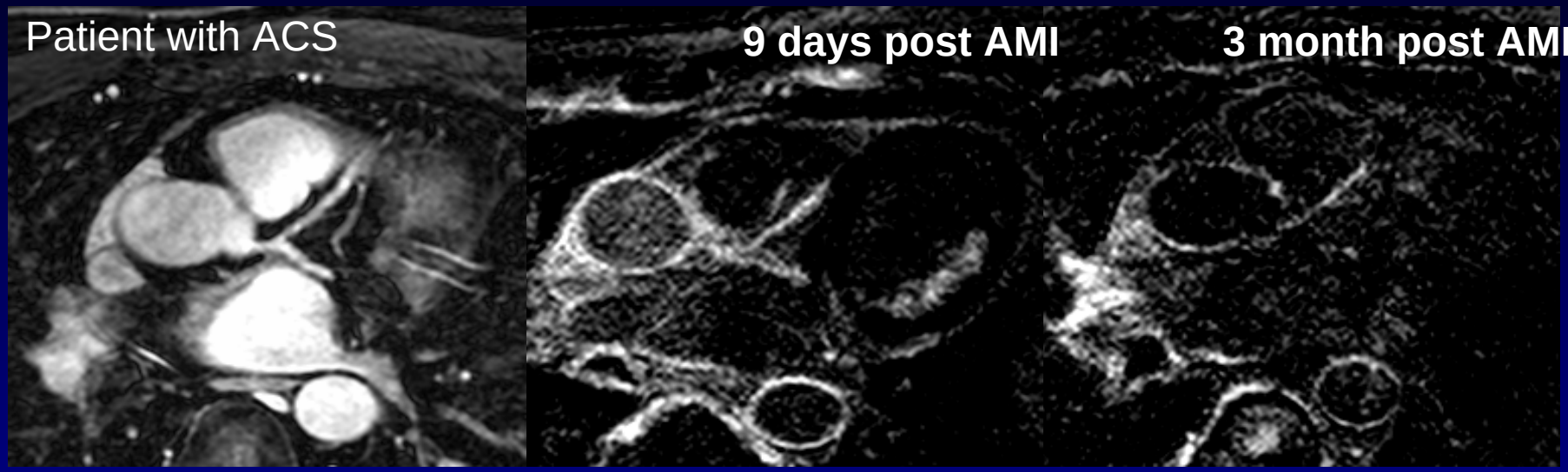
P. Gurney ISMRM 2007

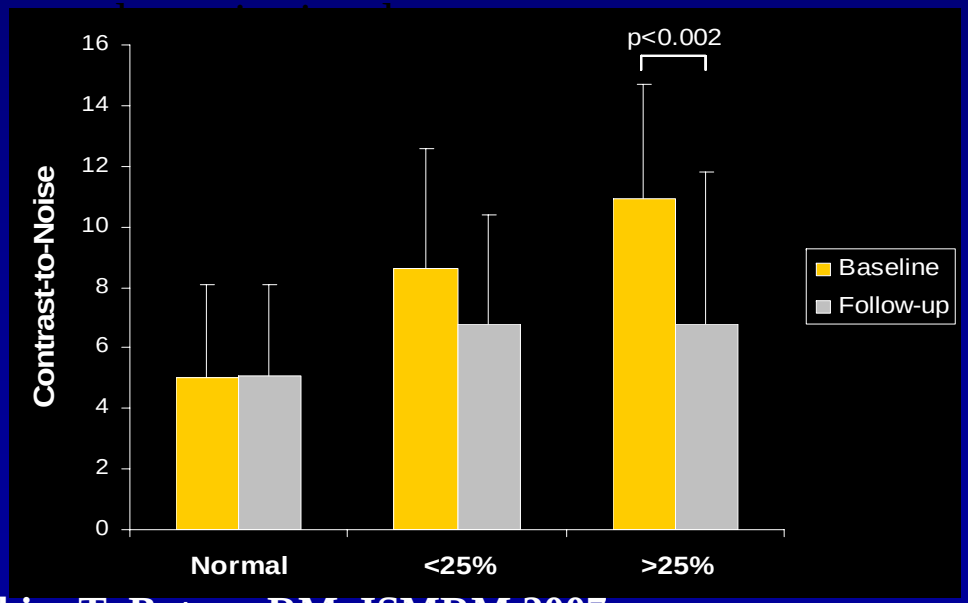


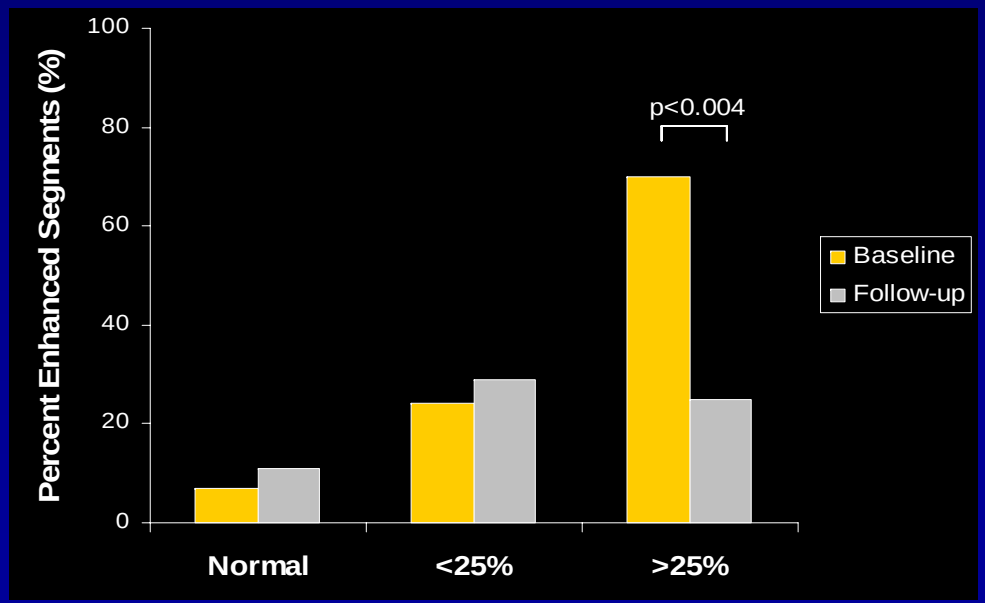


1.1 x 1.1 x 1.5 mm^3 ~10 min scan time

Contrast Enhanced Coronary MRI
"Inflammation"







Ibrahim T, Botnar RM. ISMRM 2007