Coronary and Cardiac CTA: Executive Update

April 7, 2011

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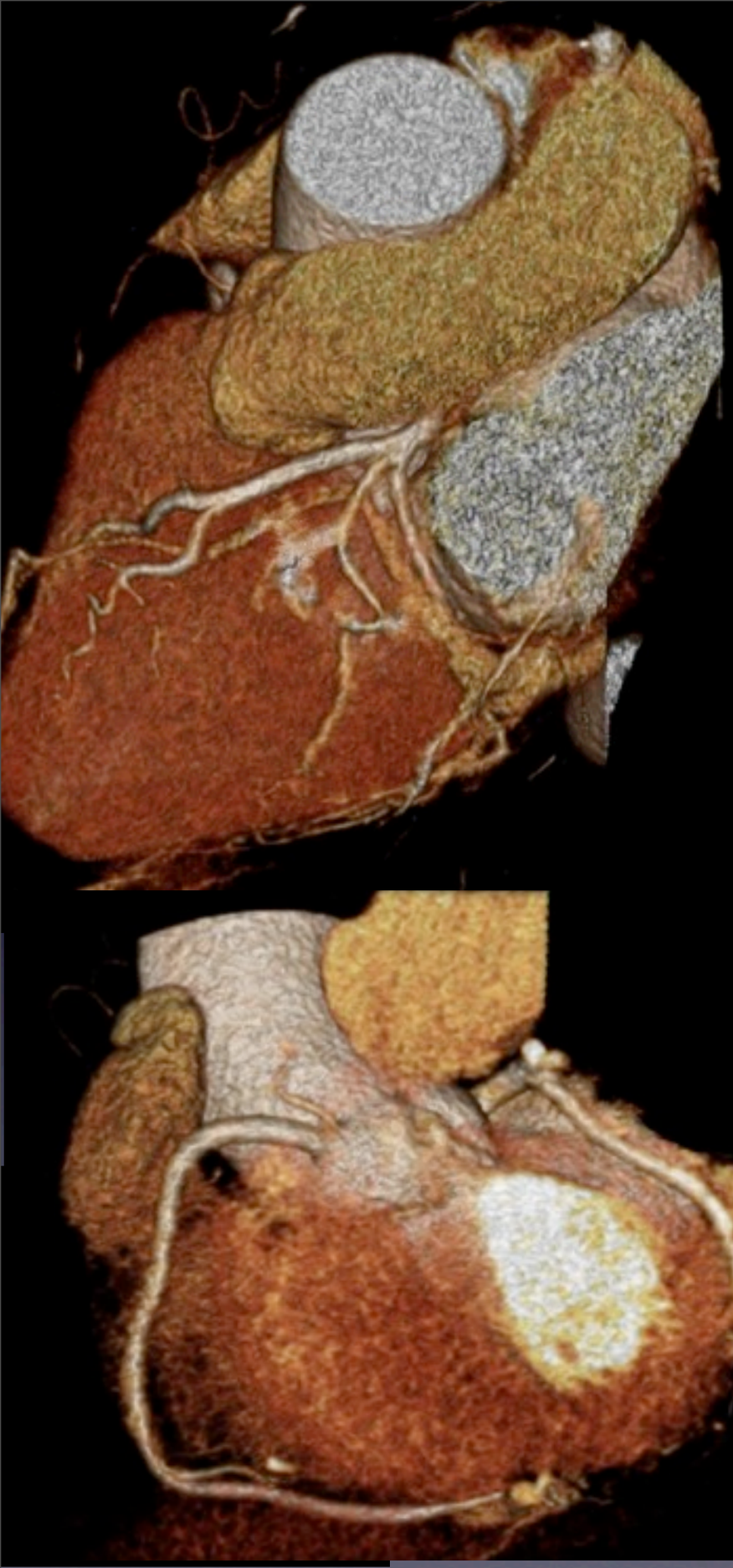
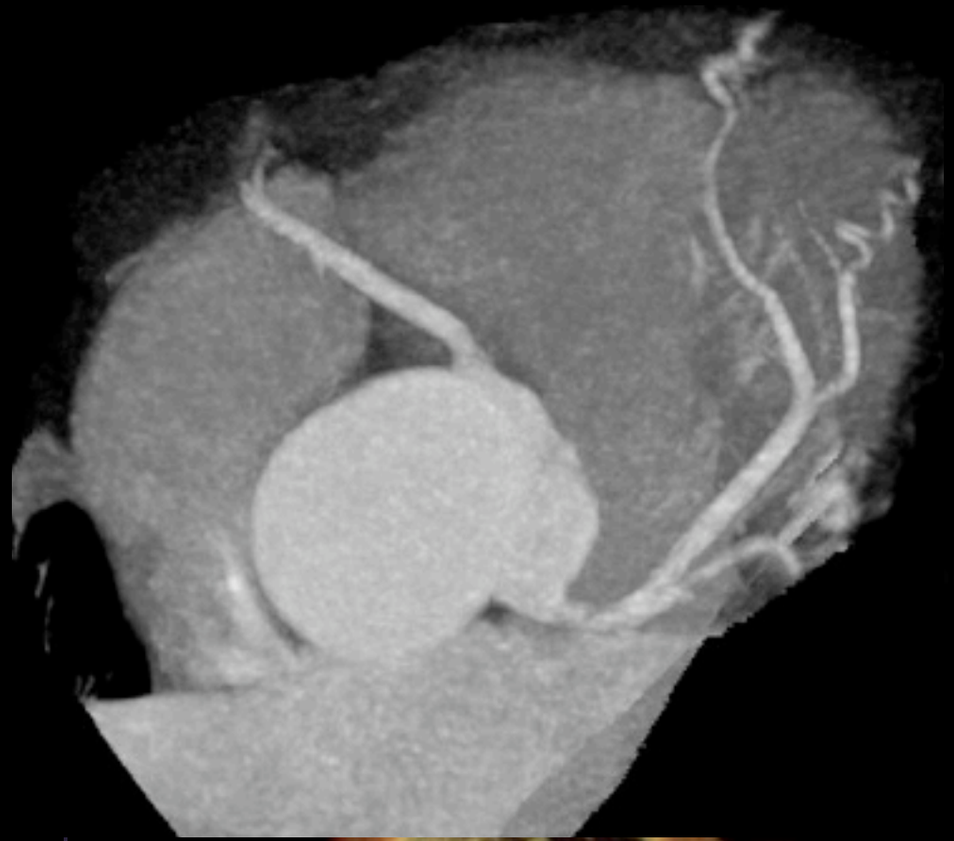
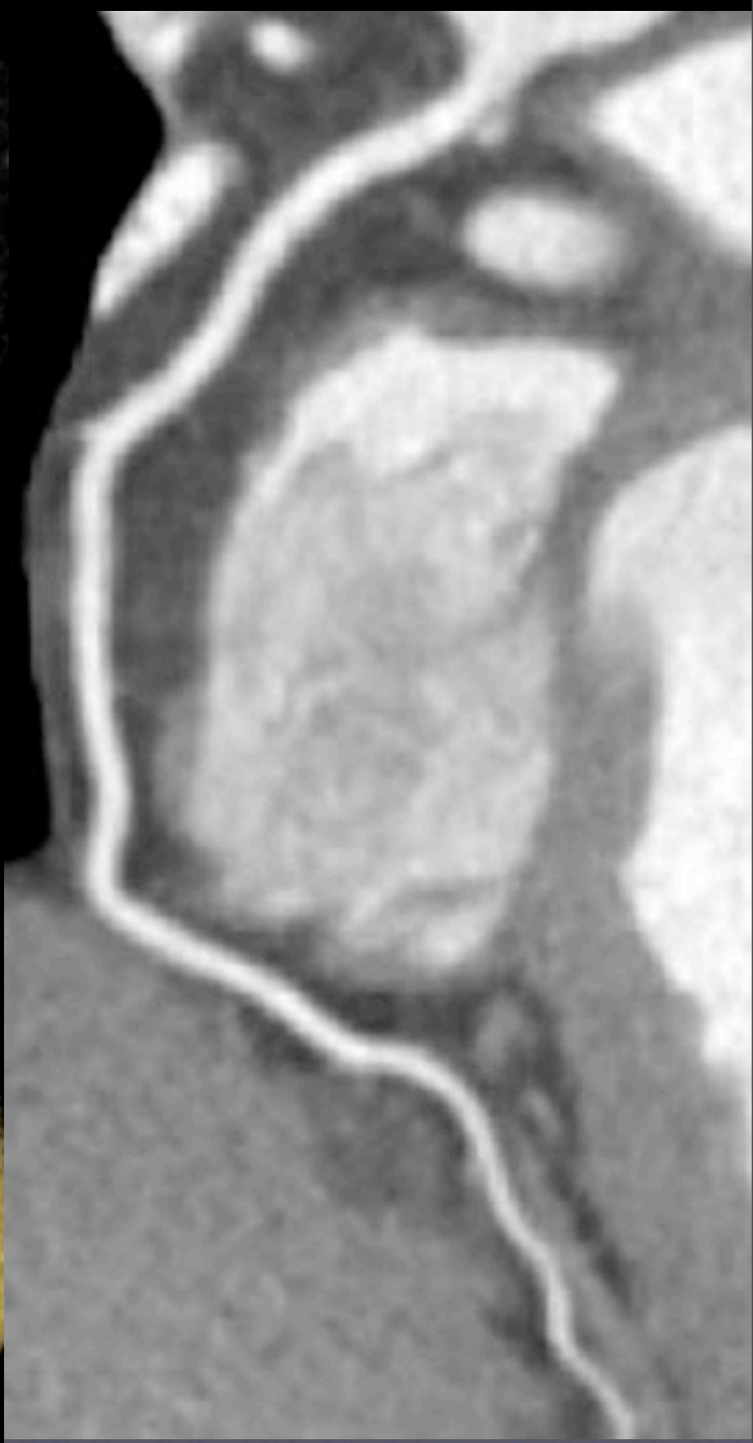
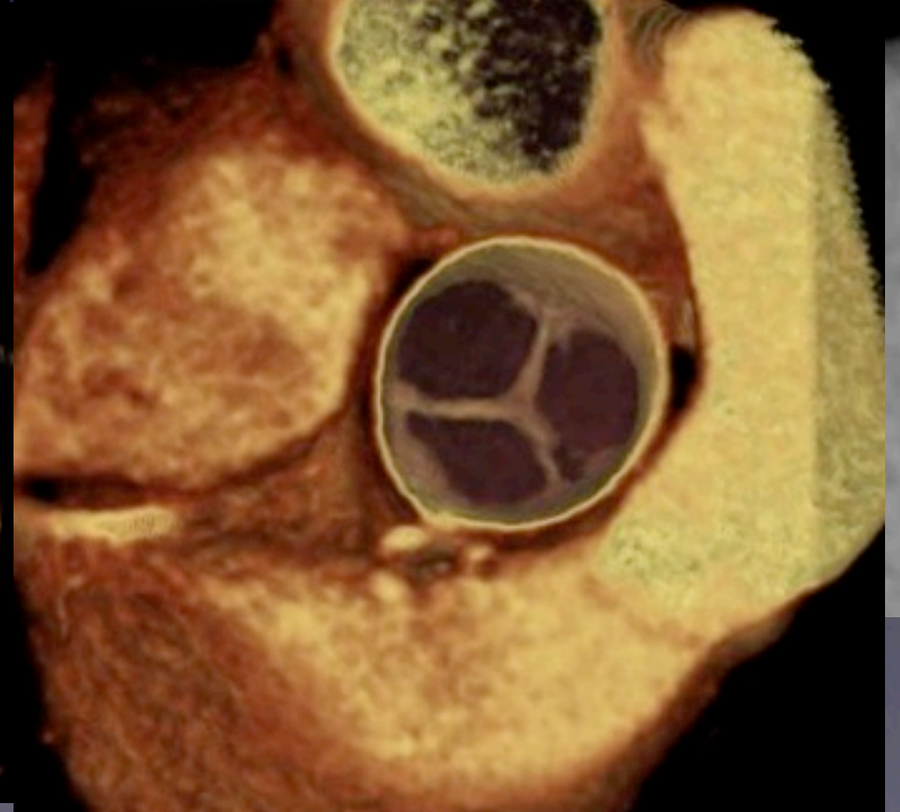
CV Imaging
Northwest Radiology Network

Cardiac Imaging is a Reality.....









Lecture Outline

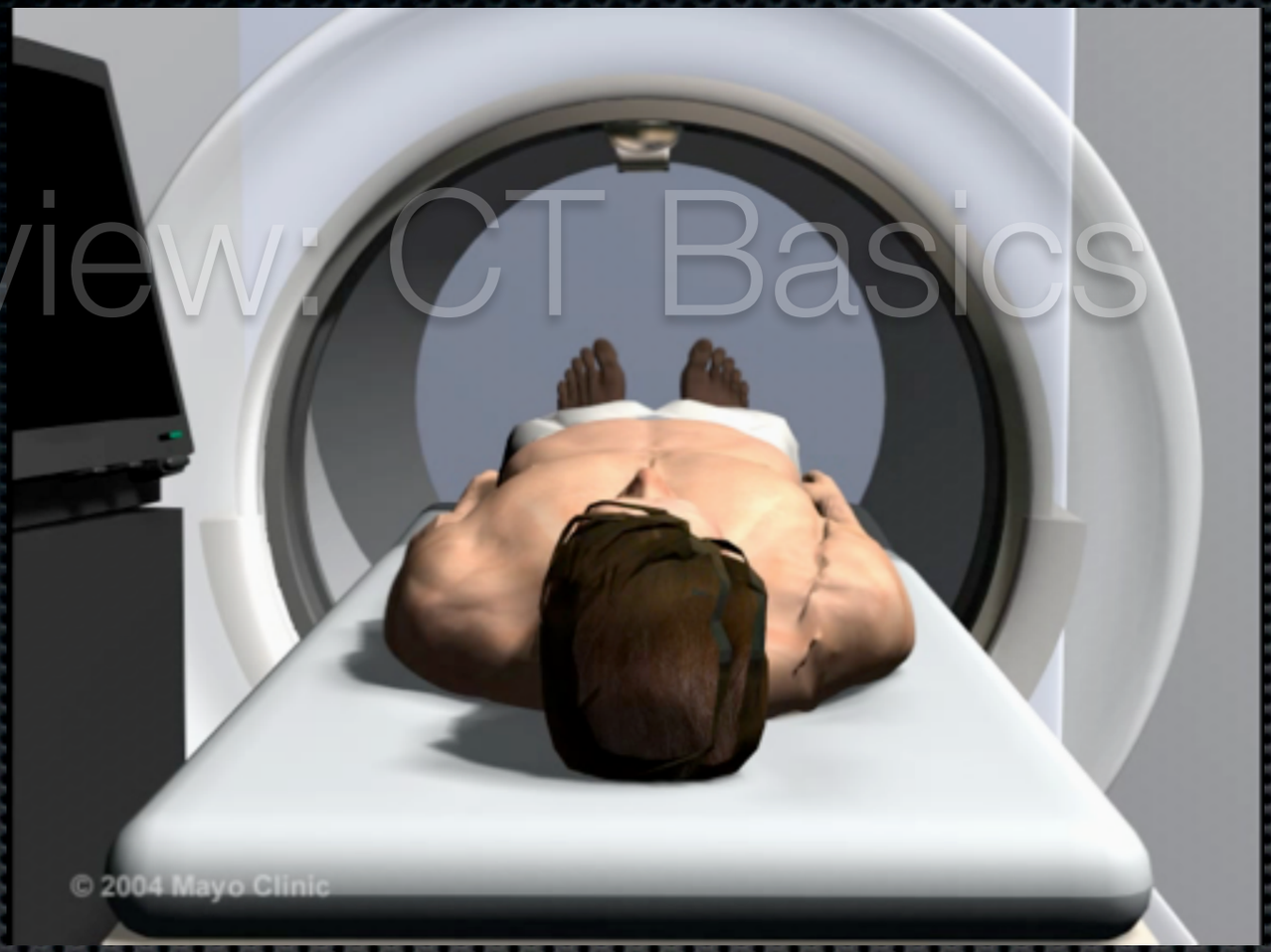
- Review of 256 slice CT
- Coronary Calcium Scoring
- Coronary CTA

Handout:
http://stanford.edu/~hallett

Overview: CT Basics

- X-Ray tube rotates- multiple detectors capture x-rays, computers reconstruct density and position
- Pixels displayed as range of :
  - *white (bone)*
  - *gray (soft tissue)*
  - *black (air)*

Overview: CT Basics



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- Pixels displayed as range of :
  - *white (bone)*
  - *gray (soft tissue)*
  - *black (air)*

CT "Area Detector" Technology

- Wide area detector - acquires a large slab of data at one time
    - Large array of many small detectors
        - Lots of slices per rotation
- Can scan one whole organ in one or two rotations of tube
- New applications (CCTA)

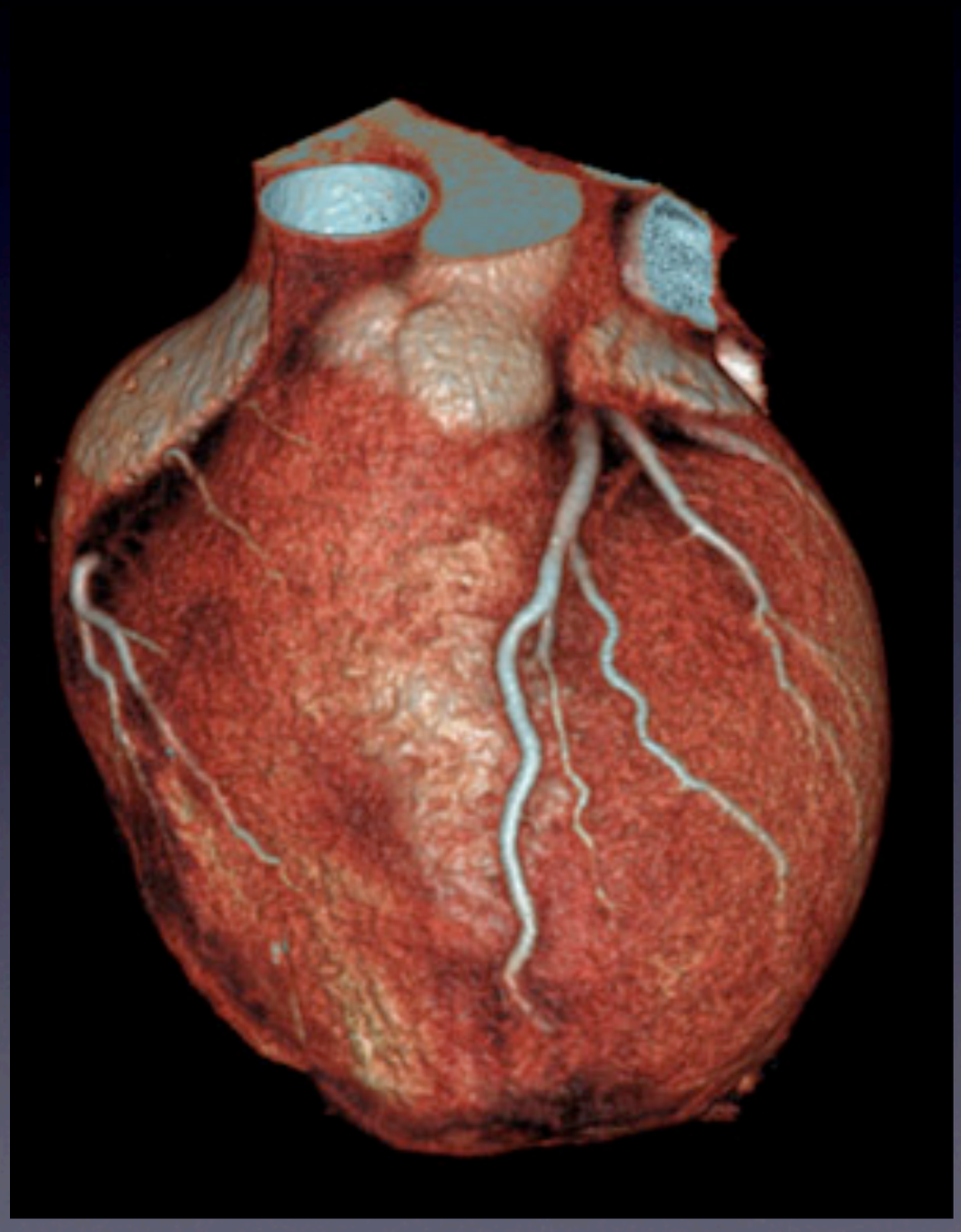
Philips iCT

Philips iCT

Philips iCT

- 128 or 256 slice wide area detector
- Fastest scanner currently available
    - rotation time = 0.27 sec (270 msec)
- High Power X-Ray tube
    - Better imaging of large patients
- New, innovative dose-reduction strategies

256 Slice Coronary CTA



Initial 256 Slice CCTA Data

- Dose ~ 4 mSv
  - cath = 5-10 mSv, 64-slice
  - CCTA = 12-20 mSv
  - 99Tc-sestamibi R/S Perf. Imaging = 15-20 mSv
  - 201 Tl stress / redist. Perf Imaging = 25-40 mSv
- 40-60% reduction in contrast medium vs 64-slice
- Less susceptible to arrhythmia vs 64-slice

Weigold, et al. Int J Cardiovasc Imaging 2009: 25:217-230

256-CT: More Assessable Coronary Segments

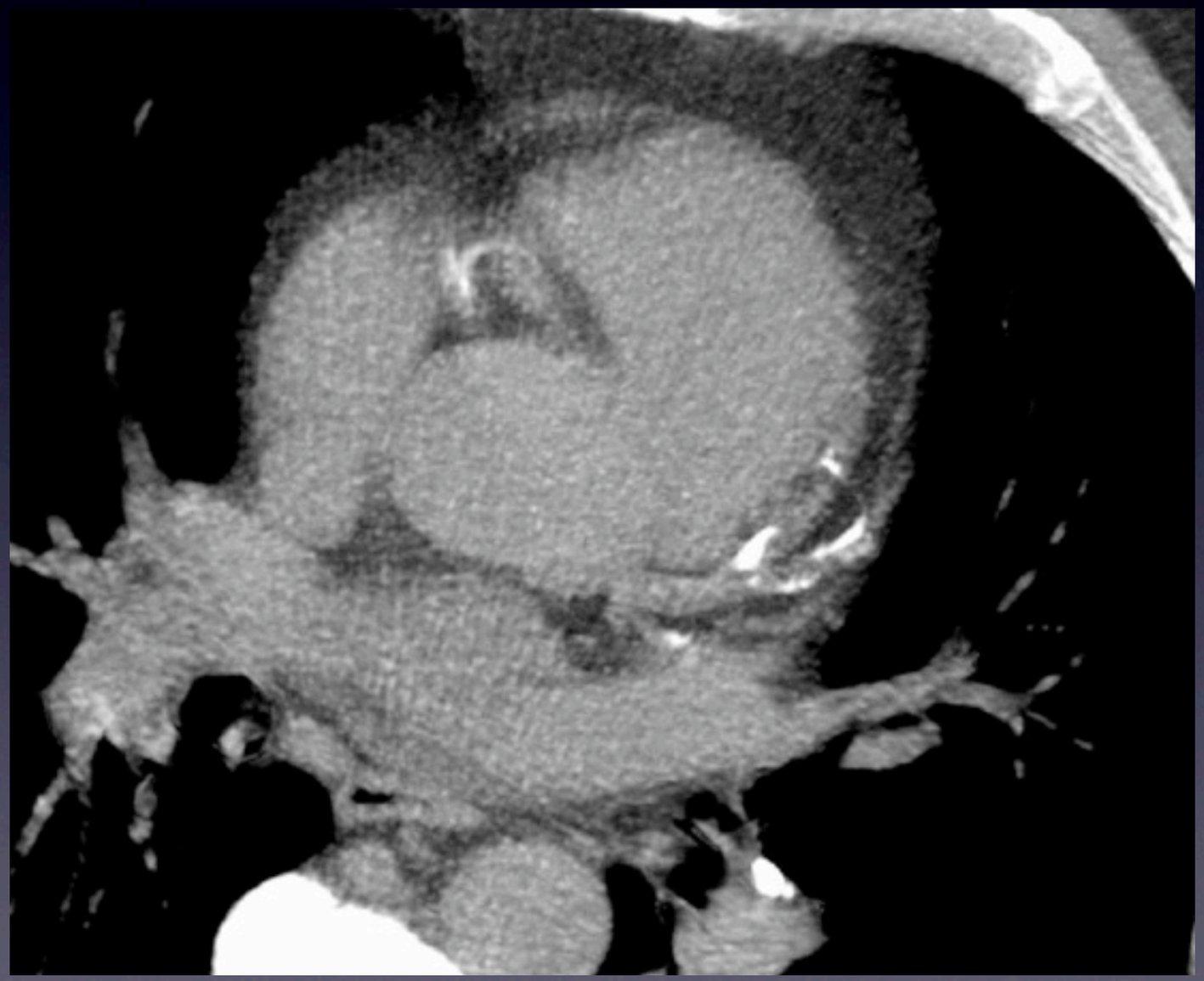
- Klass, et al. *Euro Radiol* 2009
  - 256-DCT yields more assessable segments(99%) vs 64-DCT (95%)
    - 17% less IV contrast vs. 64-DCT
- Joshi, SB et al: *Am J Cardiol* 2009
  - CCTA stenosis correlates to IVUS, no correlation to cath angio

Coronary and Cardiac CT Applications

Coronary and Cardiac CT Applications

- Coronary Artery Calcium Scoring (CAC)
- Coronary CTA (CCTA)
- "Triple Rule-Out" CTA (TRO)

Coronary Calcium Scoring (CAC)



Why Care about Coronary Calcium?

- Cardiovascular Disease is an epidemic in the U.S. and around the world
- Often subclinical, until too late
  - 40- 60% MI / sudden death occur as first events
- Can't just screen for flow-limiting stenosis
  - 70% acute events result from lesions not flow-limiting before event

CAC: Technique

- Prospective triggered, non-contrast, low-dose CT
- Define calcified plaque in coronary arteries (by density)
- "Scored":
    - Agatston: Ca^{++} pixels x weighting factor
    - Volume: mm^3
    - Mass: mg

Utility of CAC

- CAC adds independent and incremental prognostic value for risk stratification over Framingham risk score-based strategy alone
- FRS does not account for Fam Hx and many components of metabolic syndrome
- Can upgrade or downgrade 10-yr risk stratification (TX implications)

When is Calcium Scoring Appropriate?
ASYMPTOMATIC patients
ACCF / AHA Recommendations*

IIa, B • Patients with intermediate 10-year risk (Framingham, etc.) for CAD (10-20%)

IIb, B • Low- Intermediate risk (6-20%)

IIa, B • Diabetics >40

* Greenland P, et al. JACC 2010, e50-e103.

Recent CAC Results

- Rotterdam Study*
  - 2040 pts >55 yo, followed for 10y
  - intermediate 10 yr hard cardiac risk (10-20%) - Framingham
  - CAC reclassified 52% to low (<50) or high (>615) 10-yr risk
- Heinz Nixdorf Recall Study**
  - 4129 pts, 45-75 yo
  - CAC <100 and >400 reclassified ~ 20% of intermediate risk pts

*Elias-Smale SE, et al. JACC 2010;56:1407-14

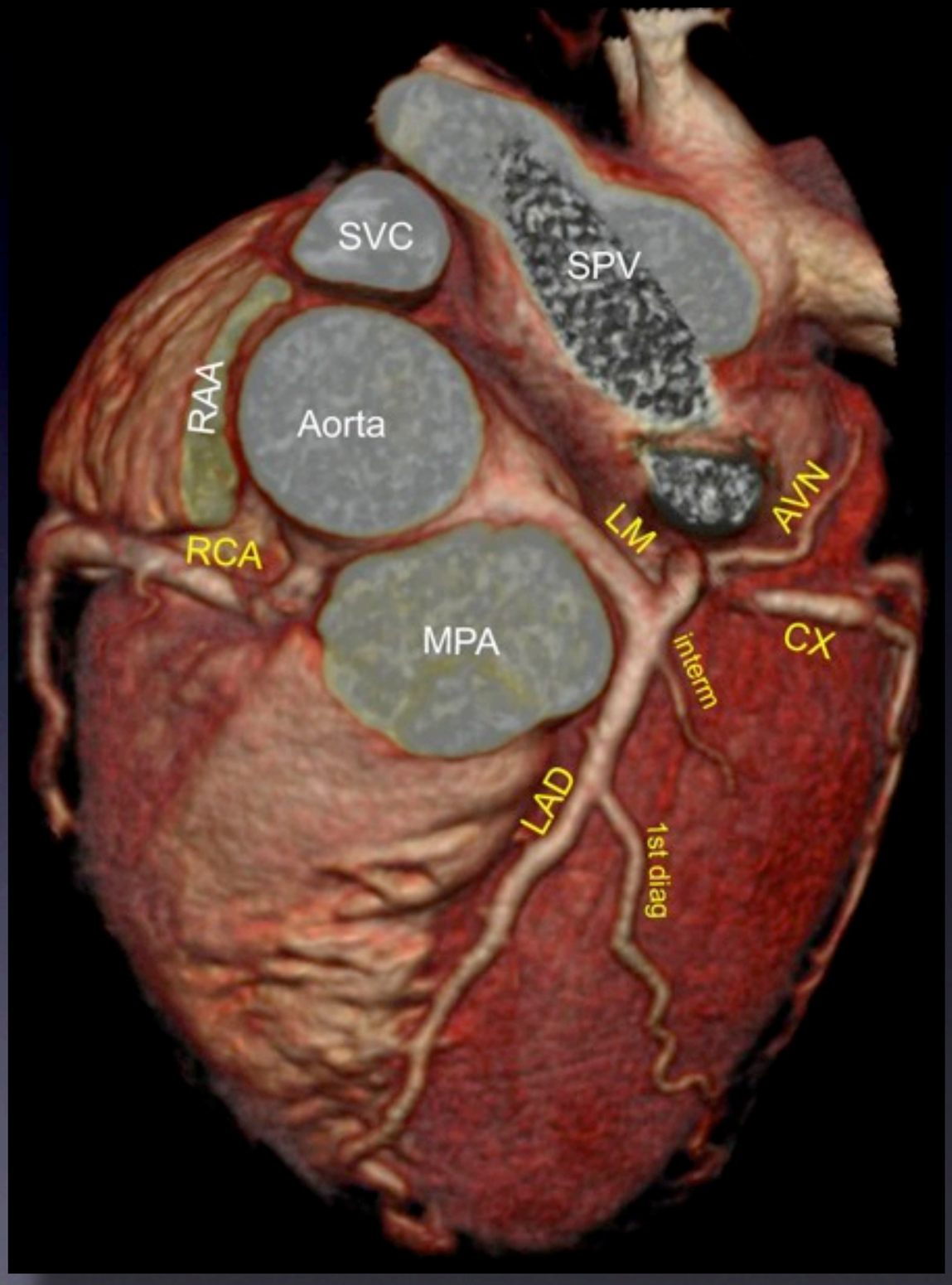
**Erbel R, et al. JACC 2010;561397-406

Recent CAC Results -2

- Long-term effect on cardiac function:
  - 386 pts ≥75 yo, No hx MI
  - Higher CAC: higher rate of RWMA and lower EF at 10 yr
  - 2.2x increased RWMA for CAC > 100

Colletti P, et al. Radiology 2010:257(1):64-70

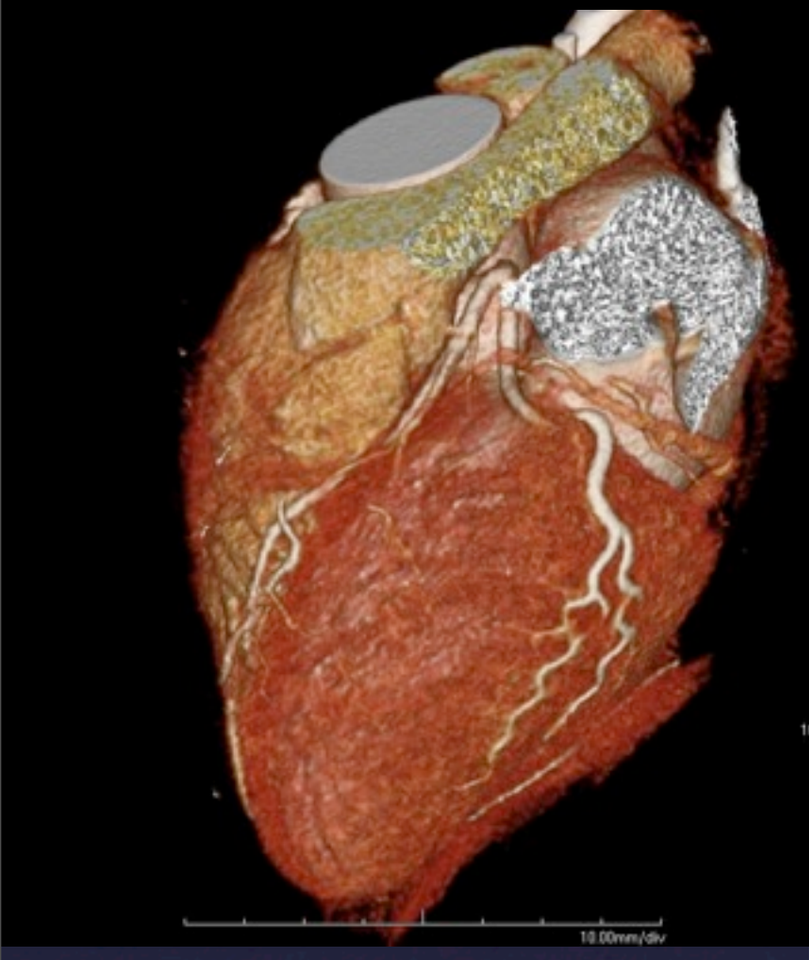
Coronary CTA (CCTA)

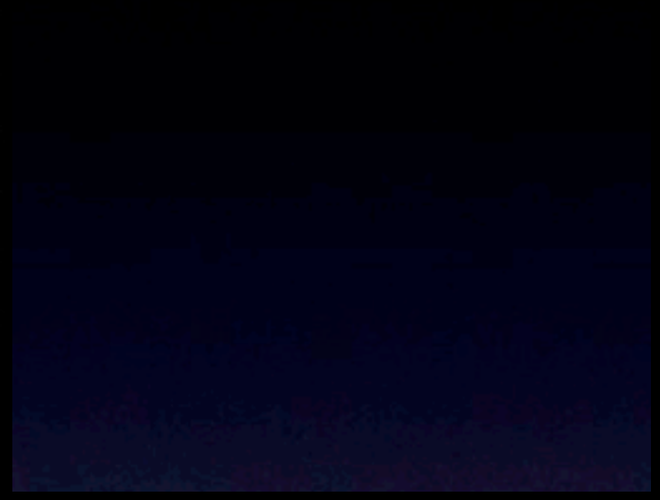


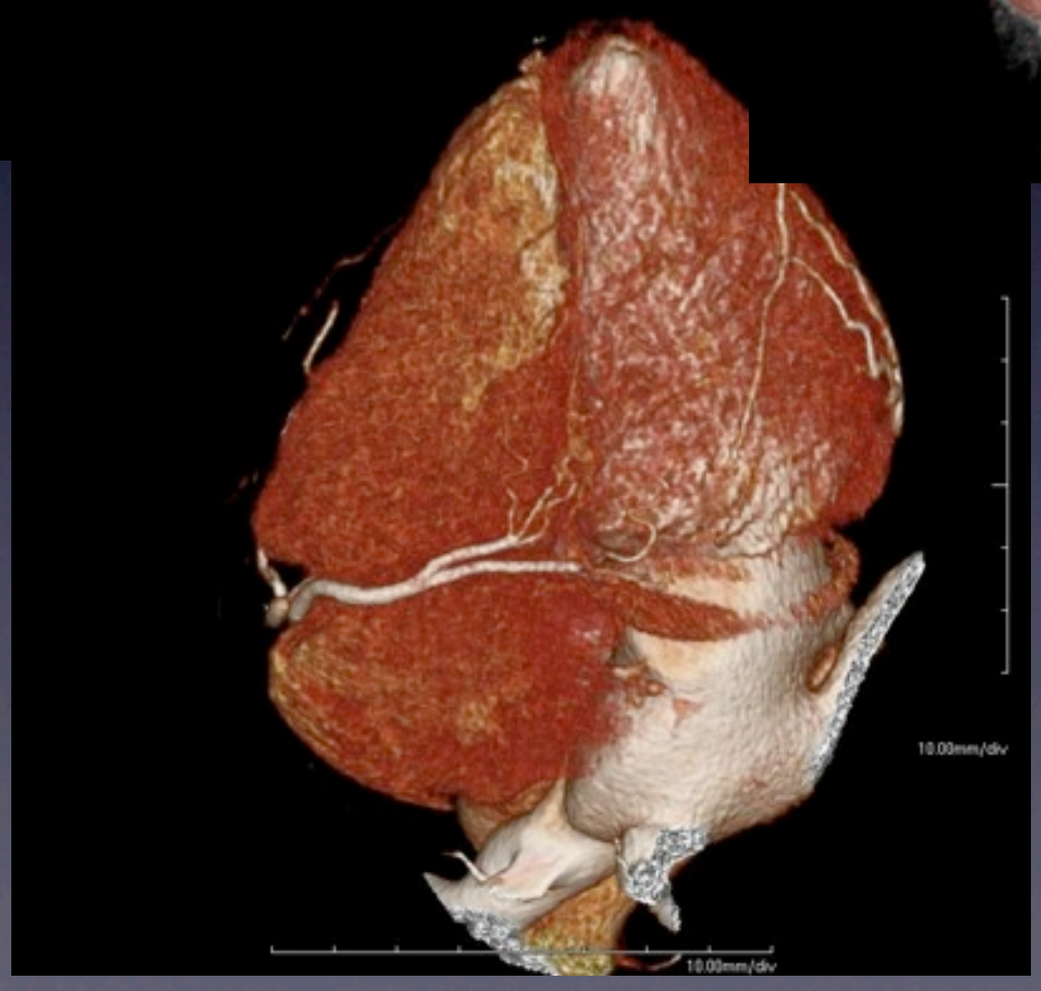
Coronary CTA:

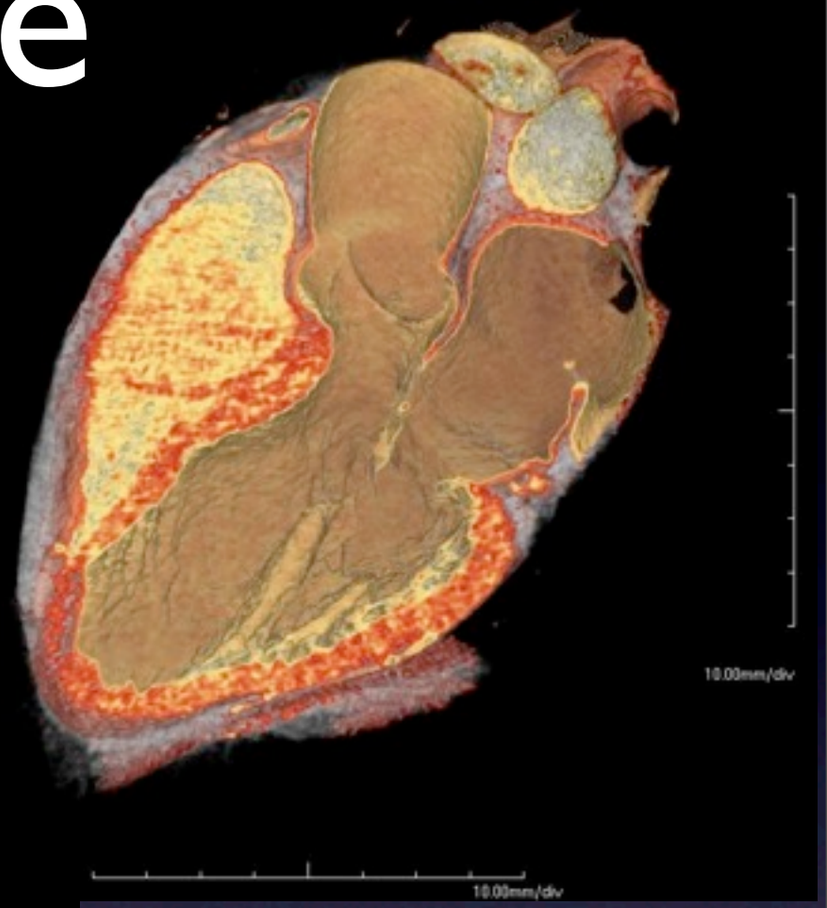
- B- Blocker
- NTG
- Can be
  - Prospectively Triggered or
  - Retrospectively Gated
- Used for patients where CAD is the primary diagnostic concern clinically

Prospective









Retrospective Gating:

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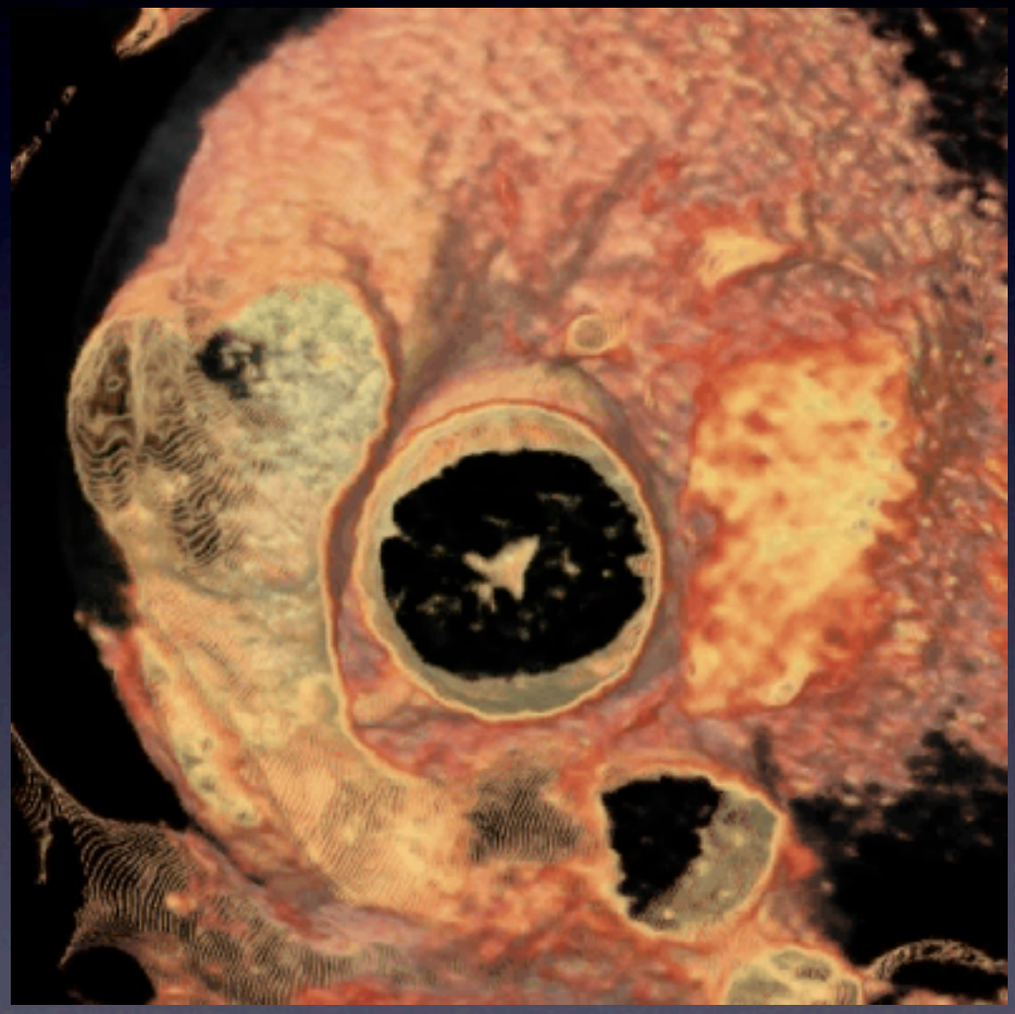
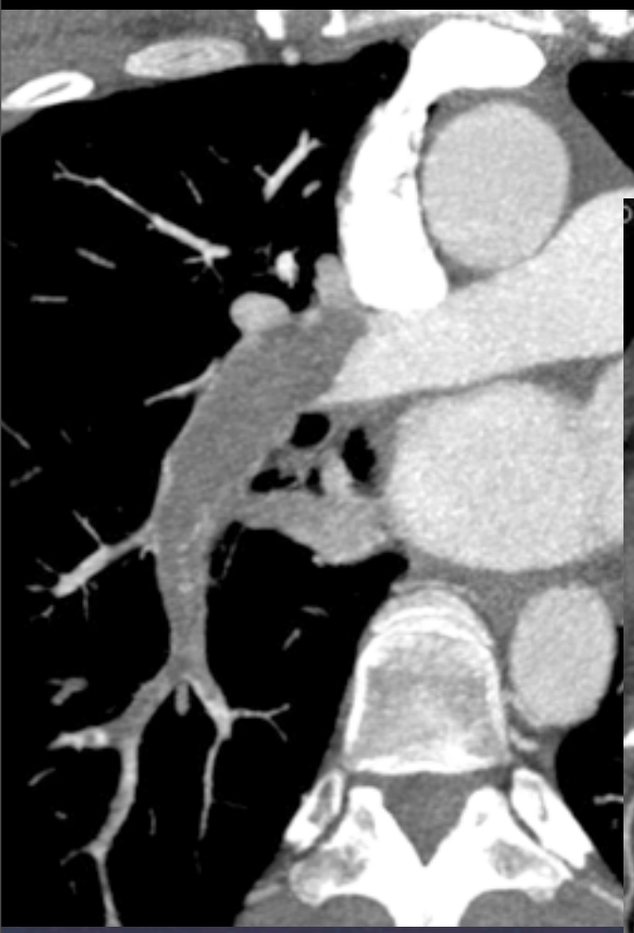
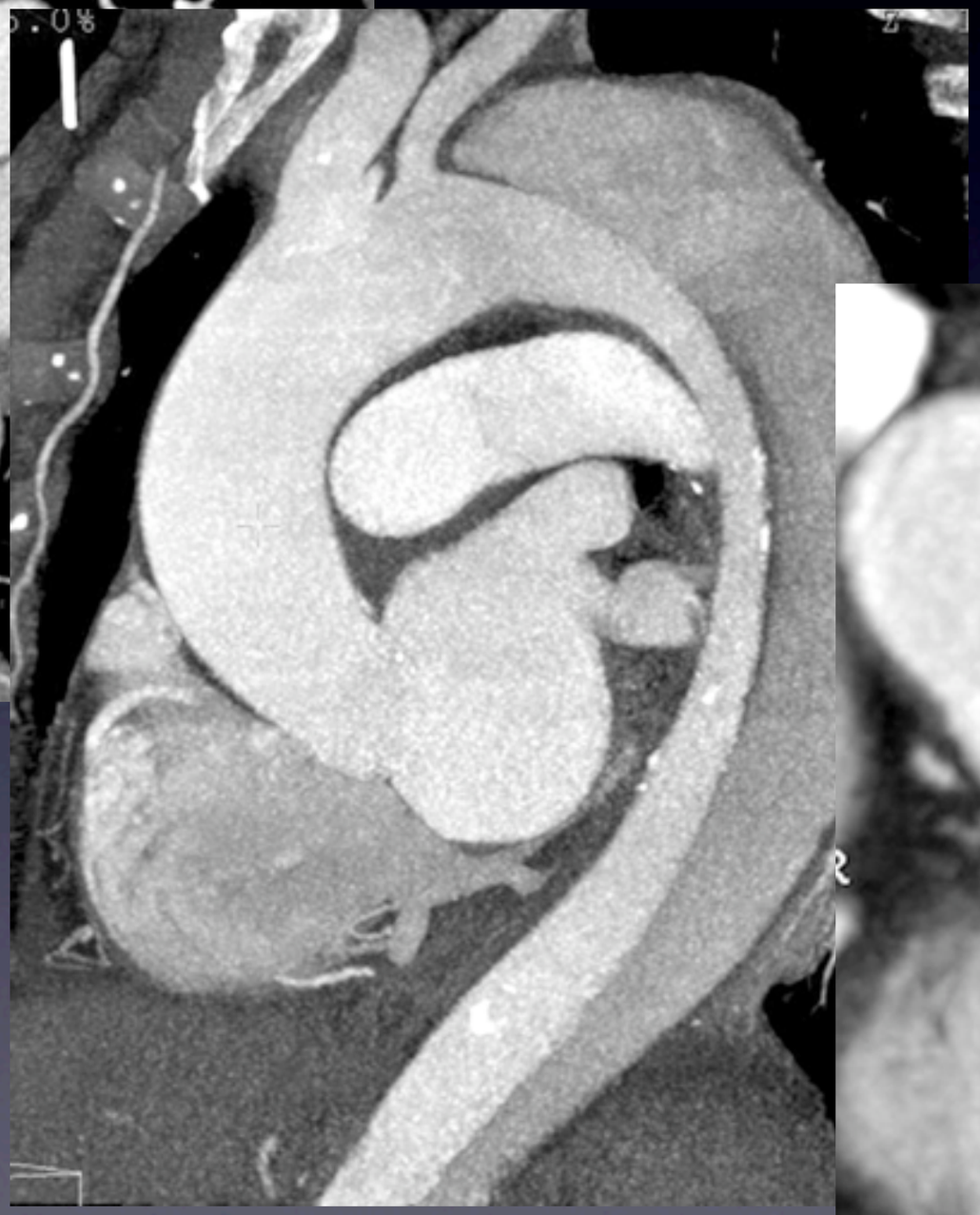


Triple Rule Out

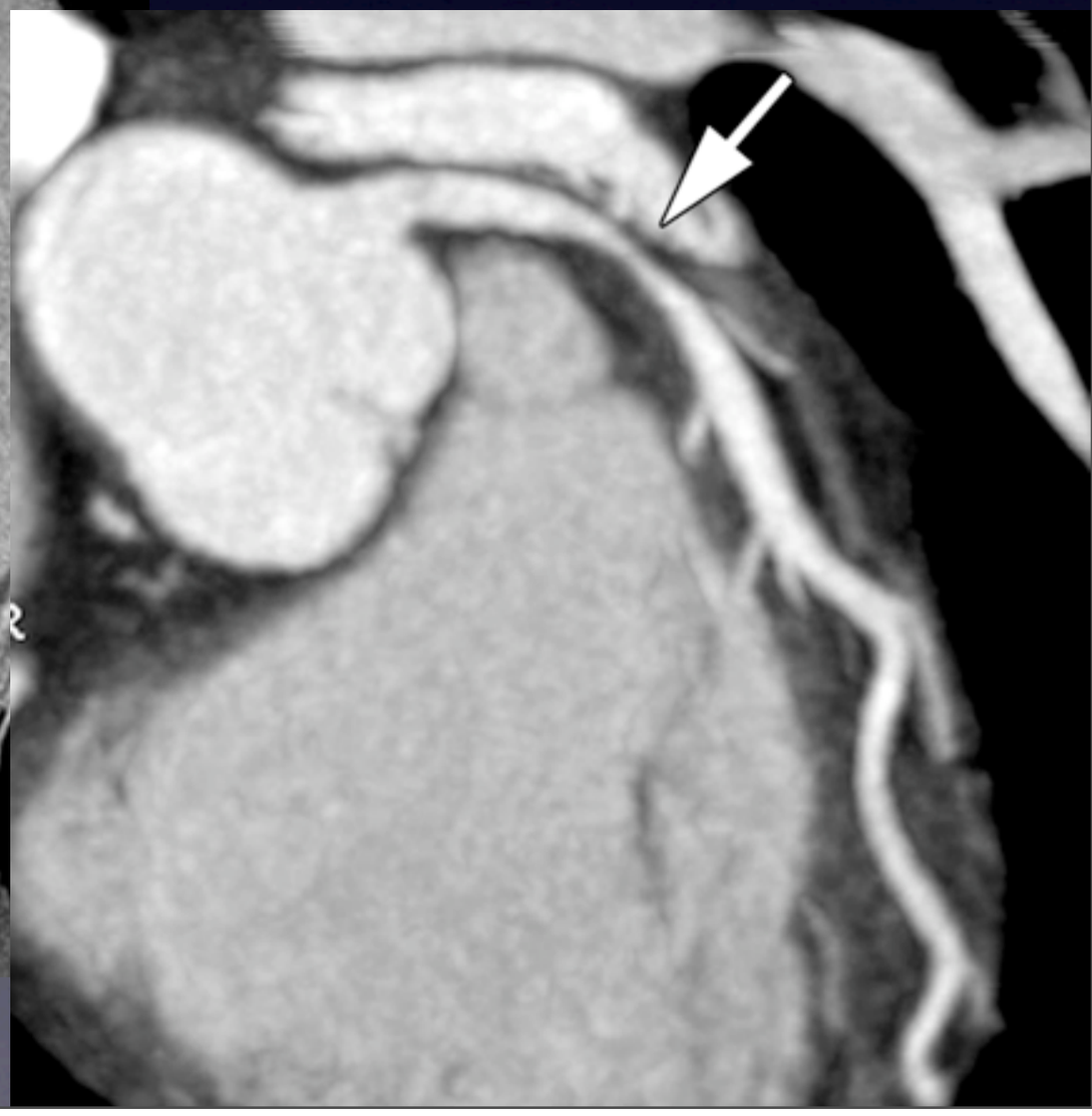
PE



DSX



Coronaries



"Triple Rule Out" CTA

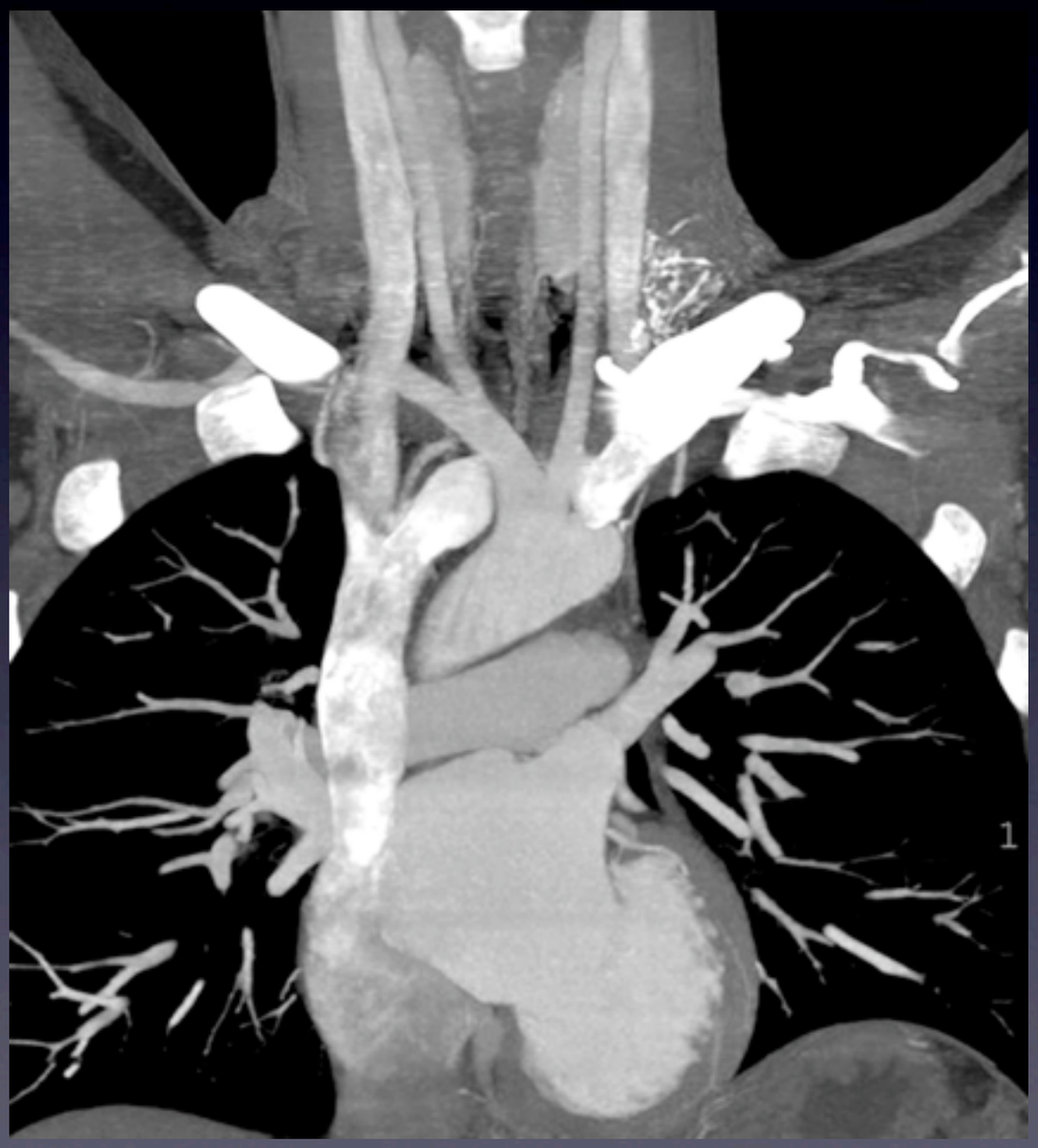
Primary goal of TRO CTA in the ED:

- **To facilitate the safe, rapid discharge of patients judged to be at low to intermediate risk of acute coronary syndrome.**

- **The detection of noncoronary lesions that explain the presenting complaint is a major advantage vs. nuclear stress testing**

- **Most appropriate and cost-effective when there is a suspicion for acute coronary syndrome along with other diagnoses such as pulmonary embolism, acute aortic syndrome, or nonvascular disease in the thorax.**

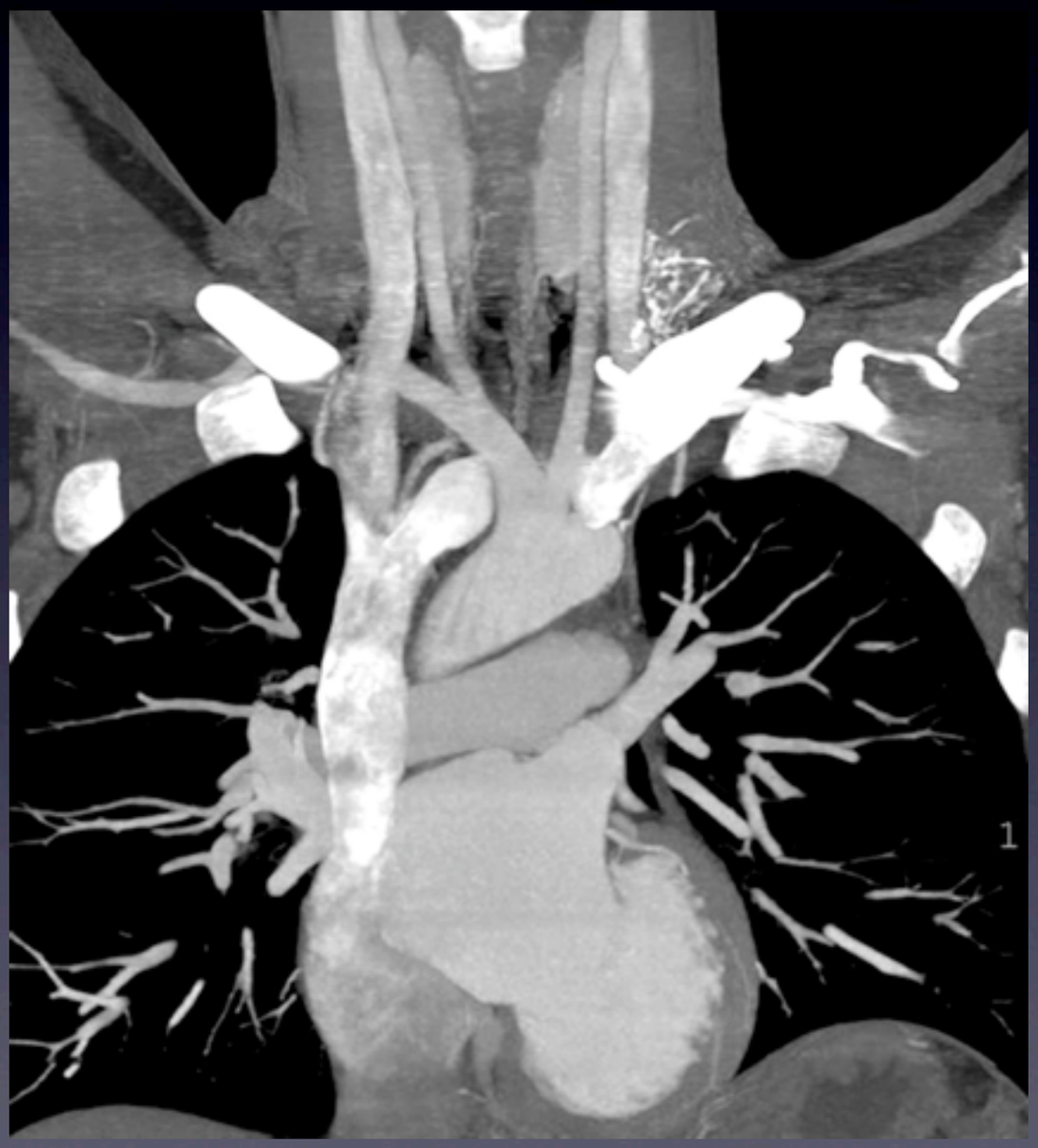
Triple Rule Out: Patient Selection



Halpern E J Radiology 2009;252:332-345

- Clinical presentation: low to moderate risk of ACS
- Clinical presentation: non-ACS diagnosis considered
- Negative biomarkers (myoglobin and troponin-I)
- Normal ECG or nonspecific changes
- No history to suggest extensive coronary calcium
- Not recommended for patients with bypass or stents
- Patient able to tolerate CT and hold breath
- Cardiac rhythm acceptable for ECG-gated scan
- Adequate renal function

Triple Rule Out: Technique



- Beta-blocker
- NTG
- Longer Acquisition
- Larger FOV
- A little more contrast
- A little more radiation

Halpern E J Radiology 2009;252:332-345

The RESULTS: High NPV for CCTA / TRO

Author	Scanner Type	No. of Patients	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Raff et al (67)	64-Section CT	70	86	95	66	98
Leschka et al (66)	64-Section CT	67	94	97	87	99
Mollet et al (69)	64-Section CT	51	99	95	76	99
Fine et al (68)	64-Section CT	66	95	96	97	92
Ropers et al (73)	64-Section CT	81	93	97	56	100
Ehara et al (70)	64-Section CT	69	90	94	89	95
Ong et al (72)	64-Section CT	134	82	96	79	96
Oncel et al (71)	64-Section CT	80	96	98	91	99
Meijboom et al (77)	64-Section CT	360	88	90	47	99
Weustink et al (76)	Dual-Source CT	100	95	95	75	99
Johnson et al (75)	Dual-Source CT	35	88	98	78	99
Leber et al (25)	Dual-Source CT	88	94	99	81	99
Ropers et al (26)	Dual-Source CT	100	92	97	68	99
Brodoefel et al (74)	Dual-Source CT	100	91	92	75	97

Bastarrika, G., Y. S. Lee, et al. (2009). "CT of coronary artery disease." Radiology **253**(2): 317-338.

Benefits: CCTA in the ED

Halpern E. Radiology 2009; 25(2):332-45

- Step-and-shoot "Triple Rule Out" can eliminate need for further diagnostic testing in 75% ED patients w/ CP
- Saves number of tests, ED triage time, ED costs, radiation dose compared to standard Tx's

Benefits: CCTA in the ED

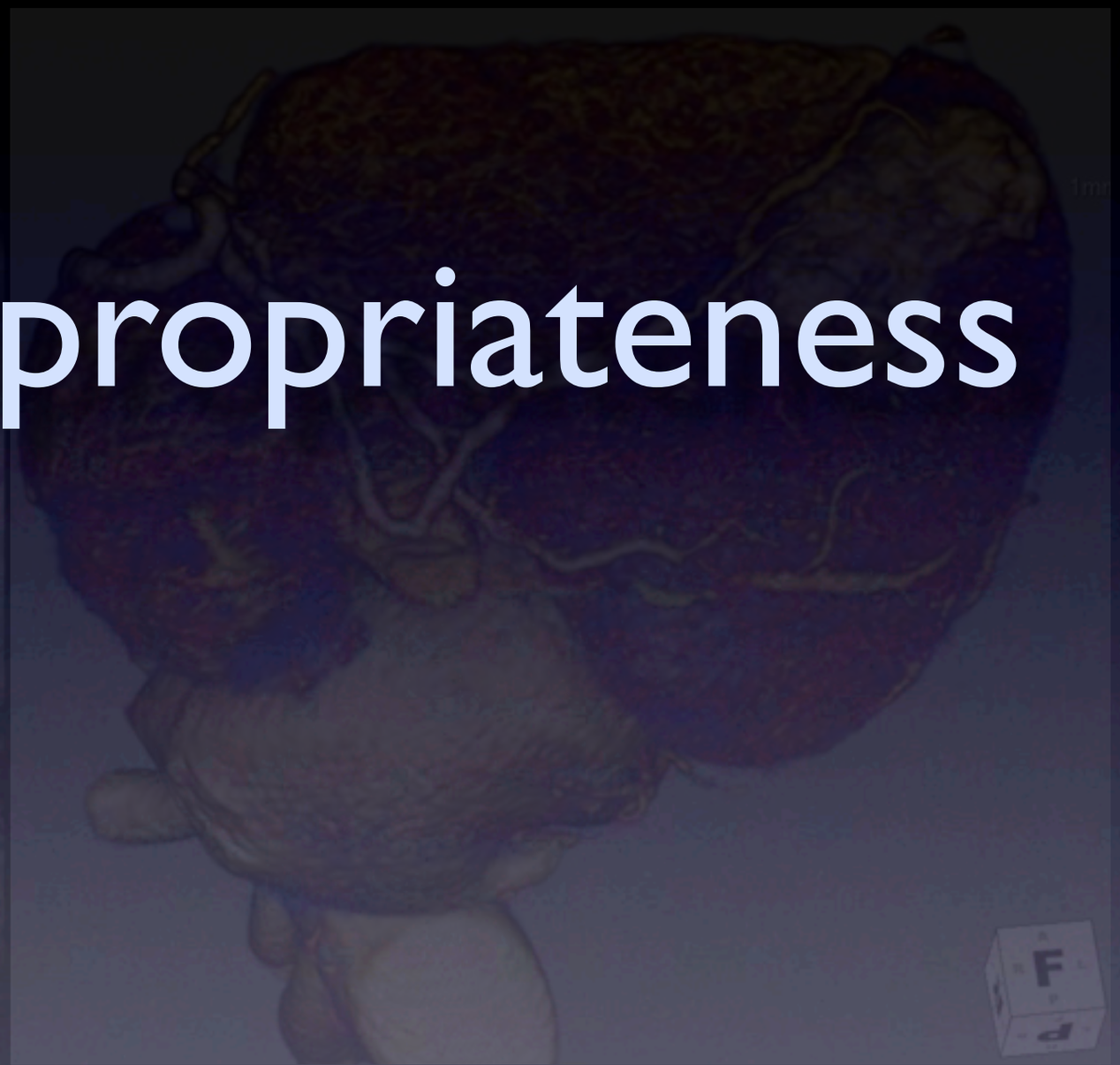
- Shuman, et al.: 1 yr follow-up on 70 pts w/ neg (<50% stenosis) CCTA through ED
  - No cardiac events at 12 months
    - 49/70 unknown
    - 9/70 GI
    - 7/70 Anxiety
    - 3/70 MSK
    - 2/70 unknown

Shuman, et al. AJR 2010: 195:1923-1927

Limitations of other imaging modalities

	SENS (%)	SPEC (%)
Stress Echo	79	87
Stress SPECT	88	73

Heijenbrok-Kal, et al: Heart J 2007 vol. 154 (3) pp. 415-23



CCTA Appropriateness

ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR 2010 Appropriate Use Criteria for Cardiac Computed Tomography

A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance

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†Official American Society of Nuclear Cardiology Representative.
‡Official Society for Cardiovascular Angiography and Interventions Representative.
§Official Society of Cardiovascular Computed Tomography Representative.
‖Official American Heart Association Representative.
¶Official American College of Radiology Representative.
#Official North American Society for Cardiovascular Imaging Representative.
**Official American Society of Echocardiography Representative.
††Official Society for Cardiovascular Magnetic Resonance Representative.
‡‡Official American College of Emergency Physicians Representative.
§§Official Heart Rhythm Society Representative.
‖‖Official Health Plan Representative.
¶¶Official American College of Physicians Representative.

This document was approved by the American College of Cardiology Foundation Board of Trustees in June 2010; by the American College of Radiology, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the Society for Cardiovascular Angiography and Interventions, the Society for Cardiovascular Magnetic Resonance, the Society of Cardiovascular Computed Tomography, and the American Heart Association in September 2010; and by the North American Society for Cardiovascular Imaging in November 2010.

The American Heart Association requests that this document be cited as follows: Taylor AJ, Cerqueira M, Hodgson JM, Mark D, Min J, O'Gara P, Rubin GD. ACCF/SCCT/ACR/AHA/ASE/ASN/NASCI/SCAI/SCMR 2010 appropriate use criteria for cardiac computed tomography: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance. *Circulation*. 2010;122:e525–e555.

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Copies: This document is available on the World Wide Web sites of the American College of Cardiology (www.cardiosource.org) and the American Heart Association (my.americanheart.org). A copy of the document is also available at http://www.americanheart.org/presenter.jhtml?identifier=3003999 by selecting either the "topic list" link or the "chronological list" link (No. KB-0105).

Expert peer review of AHA Scientific Statements is conducted at the AHA National Center. For more on AHA statements and guidelines development, visit http://www.americanheart.org/presenter.jhtml?identifier=3023366.

(*Circulation*. 2010;122:e525-e555)

Circulation is available at http://circ.ahajournals.org

DOI: 10.1161/CIR.0b013e3181fcae66

Appropriateness for CCTA: New Guidelines 2010

Previous: Hendel RC, et al. JACC 2006 48(7): 1475-97

Score 7 to 9
Appropriate test for specific indication

Score 4 to 6
Uncertain for specific indication (test **may** be generally acceptable and **may** be a reasonable approach for the indication).
May need more research

Score 1 to 3
Inappropriate test for specific indication

Taylor AJ, et al. Circulation 2010 vol. 122 (21) pp. e525-55

Symptomatic Patients

Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic—Nonacute Symptoms Possibly Representing an Ischemic Equivalent		
1.	• ECG interpretable AND • Able to exercise • Intermediate pretest probability of CAD	A (7)
2.	• ECG uninterpretable or unable to exercise • Low pretest probability of CAD	A (7)
2.	• ECG uninterpretable or unable to exercise • Intermediate pretest probability of CAD	A (8)
Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic—Acute Symptoms With Suspicion of ACS (Urgent Presentation)		
6.	• Normal ECG and cardiac biomarkers • Low pretest probability of CAD	A (7)
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8.	• Nondiagnostic ECG or equivocal cardiac biomarkers • Low pretest probability of CAD	A (7)
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Detection of CAD in other scenarios

Detection of CAD in Other Clinical Scenarios—New-Onset or Newly Diagnosed Clinical HF and No Prior CAD		
13.	• Reduced left ventricular ejection fraction • Low pretest probability of CAD	A (7)
13.	• Reduced left ventricular ejection fraction • Intermediate pretest probability of CAD	A (7)
Detection of CAD in Other Clinical Scenarios—Preoperative Coronary Assessment Prior to Noncoronary Cardiac Surgery		
15.	• Coronary evaluation before noncoronary cardiac surgery • Intermediate pretest probability of CAD	A (7)
Use of CTA in the Setting of Prior Test Results—Prior ECG Exercise Testing		
20.	• Normal ECG exercise test • Continued symptoms	A (7)
21.	• Prior ECG exercise testing • Duke Treadmill Score—intermediate risk findings	A (7)
Use of CTA in the Setting of Prior Test Results—Sequential Testing After Stress Imaging Procedures		
22.	• Discordant ECG exercise and imaging results	A (8)
23.	• Stress imaging results: equivocal	A (8)

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Detection of CAD in other scenarios

Use of CTA in the Setting of Prior Test Results—Evaluation of New or Worsening Symptoms in the Setting of Past Stress Imaging Study		
29.	• Previous stress imaging study normal	A (8)
Risk Assessment Postrevascularization (PCI or CABG)—Symptomatic (Ischemic Equivalent)		
39.	• Evaluation of graft patency after CABG	A (8)
Risk Assessment Postrevascularization (PCI or CABG)—Asymptomatic—Prior Coronary Stenting		
43.	• Prior left main coronary stent with stent diameter ≥3 mm	A (7)

Taylor AJ, et al. Circulation 2010 vol. 122 (21) pp. e525-55

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Use of CTA in the Setting of Prior Test Results—Evaluation of New or Worsening Symptoms in the Setting of Past Stress Imaging Study		
29.	• Previous stress imaging study normal	A (8)

Risk Assessment Postrevascularization (PCI or CABG)—Symptomatic (Ischemic Equivalent)		
39.	• Evaluation of graft patency after CABG	A (8)

Risk Assessment Postrevascularization (PCI or CABG)—Asymptomatic—Prior Coronary Stenting		
43.	• Prior left main coronary stent with stent diameter ≥3 mm	A (7)

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Cardiac Structure and Function

Evaluation of Cardiac Structure and Function—Adult Congenital Heart Disease		
46.	• Assessment of anomalies of coronary arterial and other thoracic arteriovenous vessels	A (9)
47.	• Assessment of complex adult congenital heart disease	A (8)

Evaluation of Cardiac Structure and Function—Evaluation of Ventricular Morphology and Systolic Function		
49.	• Evaluation of left ventricular function • Following acute MI or in HF patients • Inadequate images from other noninvasive methods	A (7)
50.	• Quantitative evaluation of right ventricular function	A (7)
51.	• Assessment of right ventricular morphology • Suspected arrhythmogenic right ventricular dysplasia	A (7)

Evaluation of Cardiac Structure and Function—Evaluation of Intra- and Extracardiac Structures		
53.	• Characterization of native cardiac valves • Suspected clinically significant valvular dysfunction • Inadequate images from other noninvasive methods	A (8)
54.	• Characterization of prosthetic cardiac valves • Suspected clinically significant valvular dysfunction • Inadequate images from other noninvasive methods	A (8)
56.	• Evaluation of cardiac mass (suspected tumor or thrombus) • Inadequate images from other noninvasive methods	A (8)
57.	• Evaluation of pericardial anatomy	A (8)
58	• Evaluation of pulmonary vein anatomy • Prior to radiofrequency ablation for atrial fibrillation	A (8)
59.	• Noninvasive coronary vein mapping • Prior to placement of biventricular pacemaker	A (8)
60.	• Localization of coronary bypass grafts and other retrosternal anatomy • Prior to reoperative chest or cardiac surgery	A (8)

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SUMMARY:

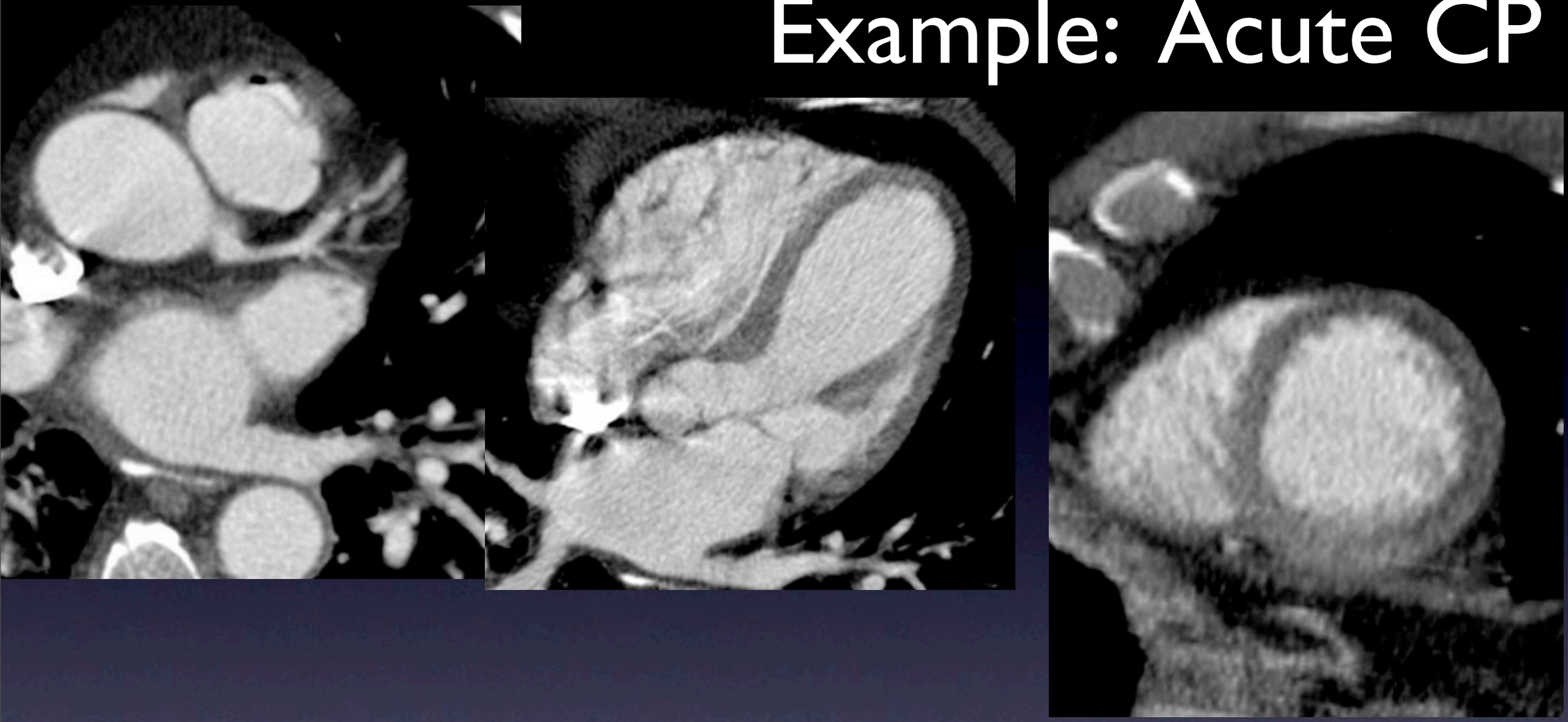
APPROPRIATE INDICATIONS: CORONARY AND CARDIAC CT

CLINICAL SCENARIO	FOR THESE INDICATIONS:	ORDER
NON-ACUTE SX (WITHOUT KNOWN HEART DZ)	•Low or Intermediate Pretest Probability *+/- ECG uninterpretable +/- can exercise*	**CCTA**
ACUTE or URGENT SX (WITHOUT KNOWN HEART DZ)	•Low or Intermediate Pre-test Probability *Negative, Non-diagnostic or Equivocal Biomarkers and/or ECG*	**CCTA**
New Onset CHF (WITHOUT KNOWN HEART DZ)	•LOW or INTERMEDIATE Pretest Probability	**CCTA**
SYMPTOMATIC PT	•Evaluate suspected coronary Anomalies	**CCTA**
PRE-OP NON-CORONARY CARDIAC SURGERY (WITHOUT KNOWN HEART DZ)	Intermediate Pretest Probability	**CCTA**
PRIOR STRESS TESTS	•CONTINUING OR WORSENING SYMPTOMS •DISCORDANT STRESS ECG / IMAGING •EQUIVOCAL STRESS IMAGING	**CCTA**
•**CARDIAC MASS / THROMBUS** •**VALVULAR DISEASES** •**PERICARDIAL EVALUATION**	•If limited info from Echo, TEE, or MRI (problem solving) •For Morphology and/or Function Calculation	**Cardiac CT** (no B-blocker or NTG)
CORONARY ARTERY BYPASS GRAFT MAPPING	Prior to Re-Do CABG (to assess positions and patency of bypass grafts- esp. LIMA)	**CTA CHEST-BYPASS GRAFT**
CORONARY CALCIUM SCORE	•Low-Intermediate Pretest Probability •Intermediate Pretest Probability •Diabetics >40 yr old	**Coronary Calcium Scoring CT**
CONTRAINDICATIONS to CORONARY CTA: (MOST ARE RELATIVE)	•Weight >300 lbs •Calcium Score >500 •Iodine (Contrast) allergy (and not pre-medicated) •Contraindication to B-blocker, NTG •Severe Asthma or COPD •AFIB	

Adapted from:
Taylor AJ, et al. Circulation 2010 (21) pp. e525-55

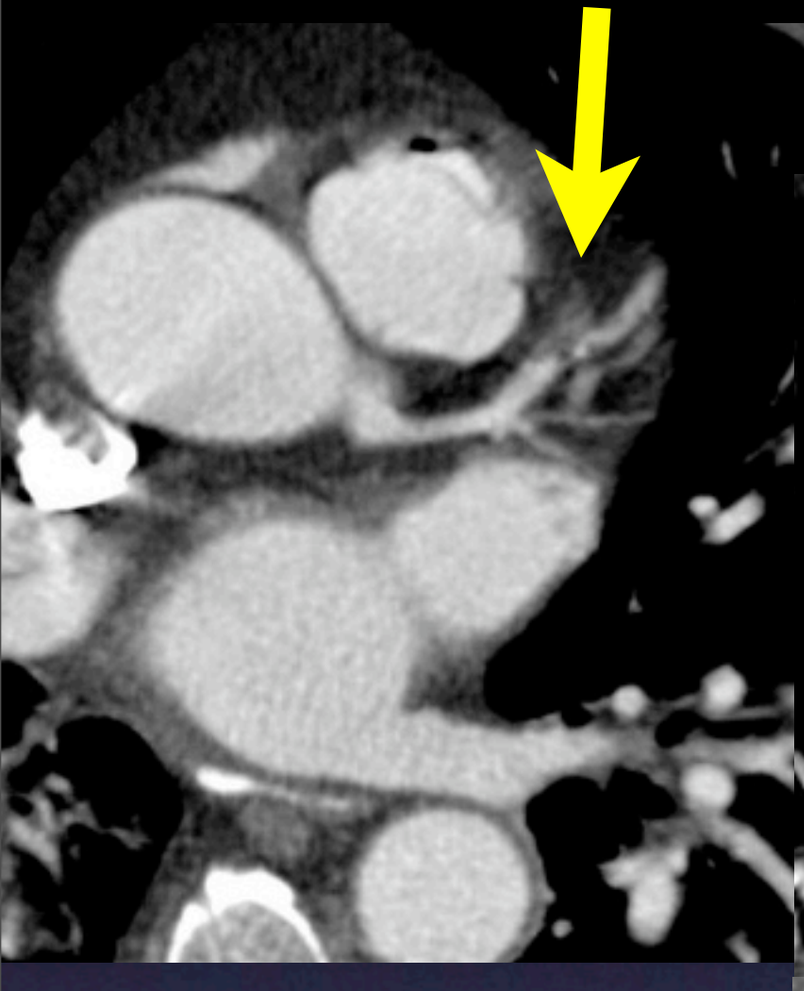
Example Cases

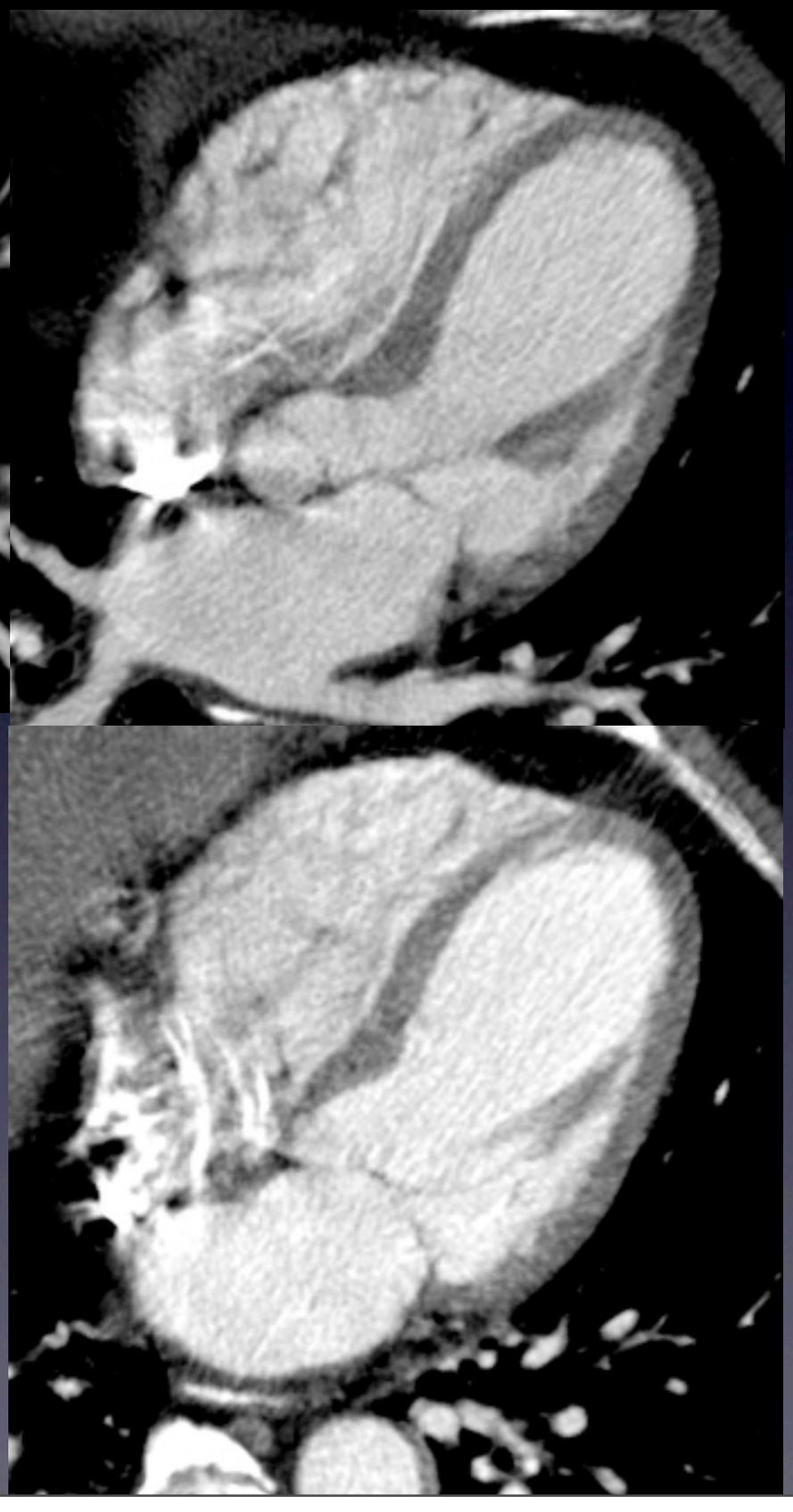
Example: Acute CP

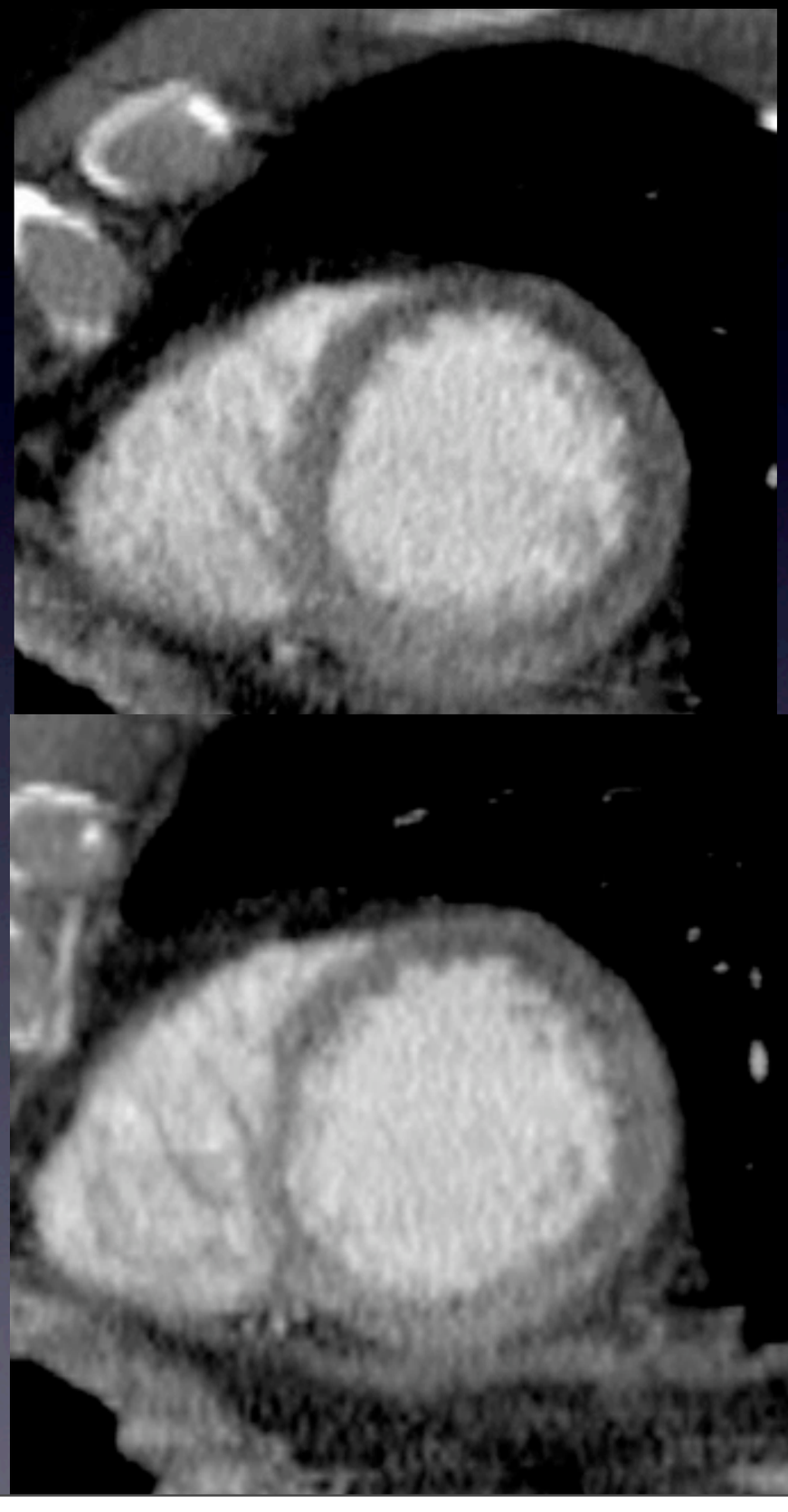


CCTA

Example: Acute CP

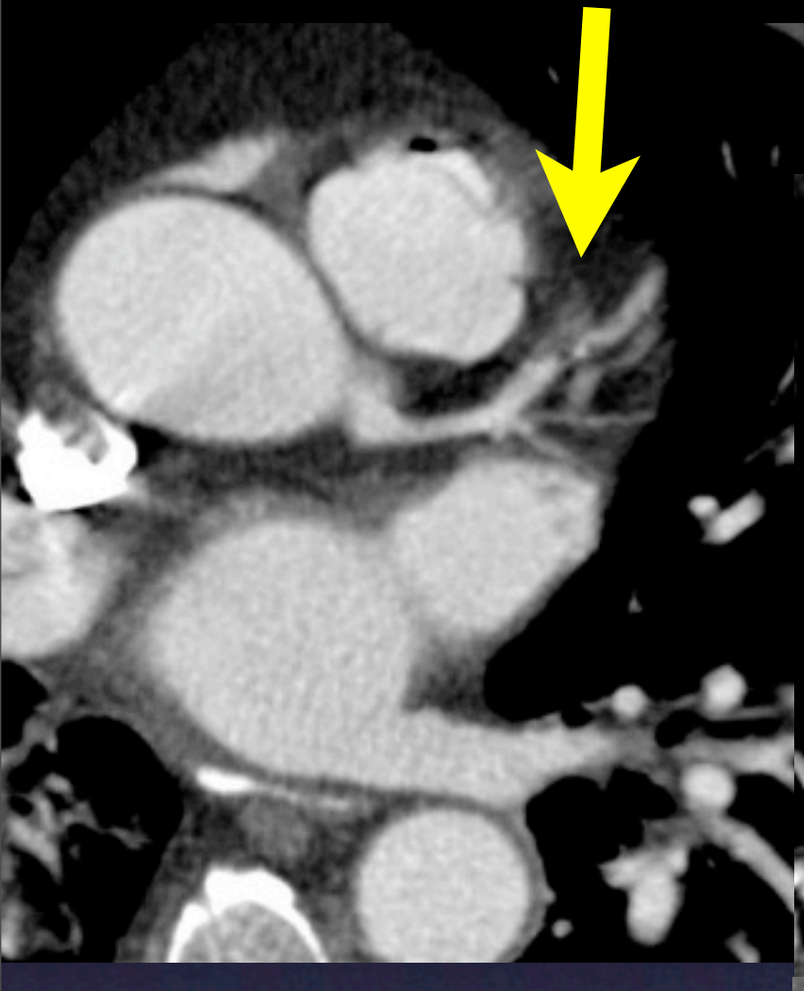


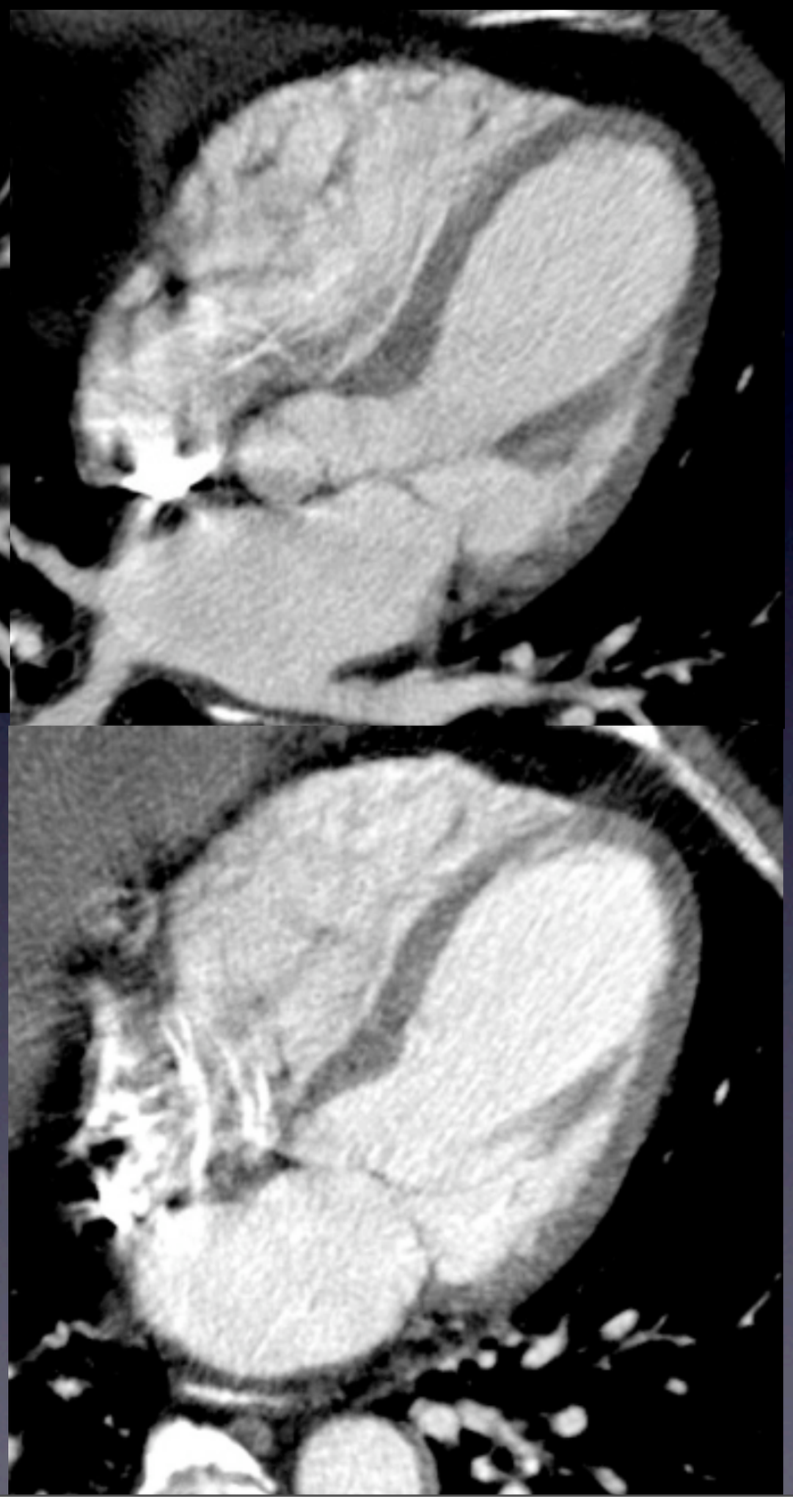


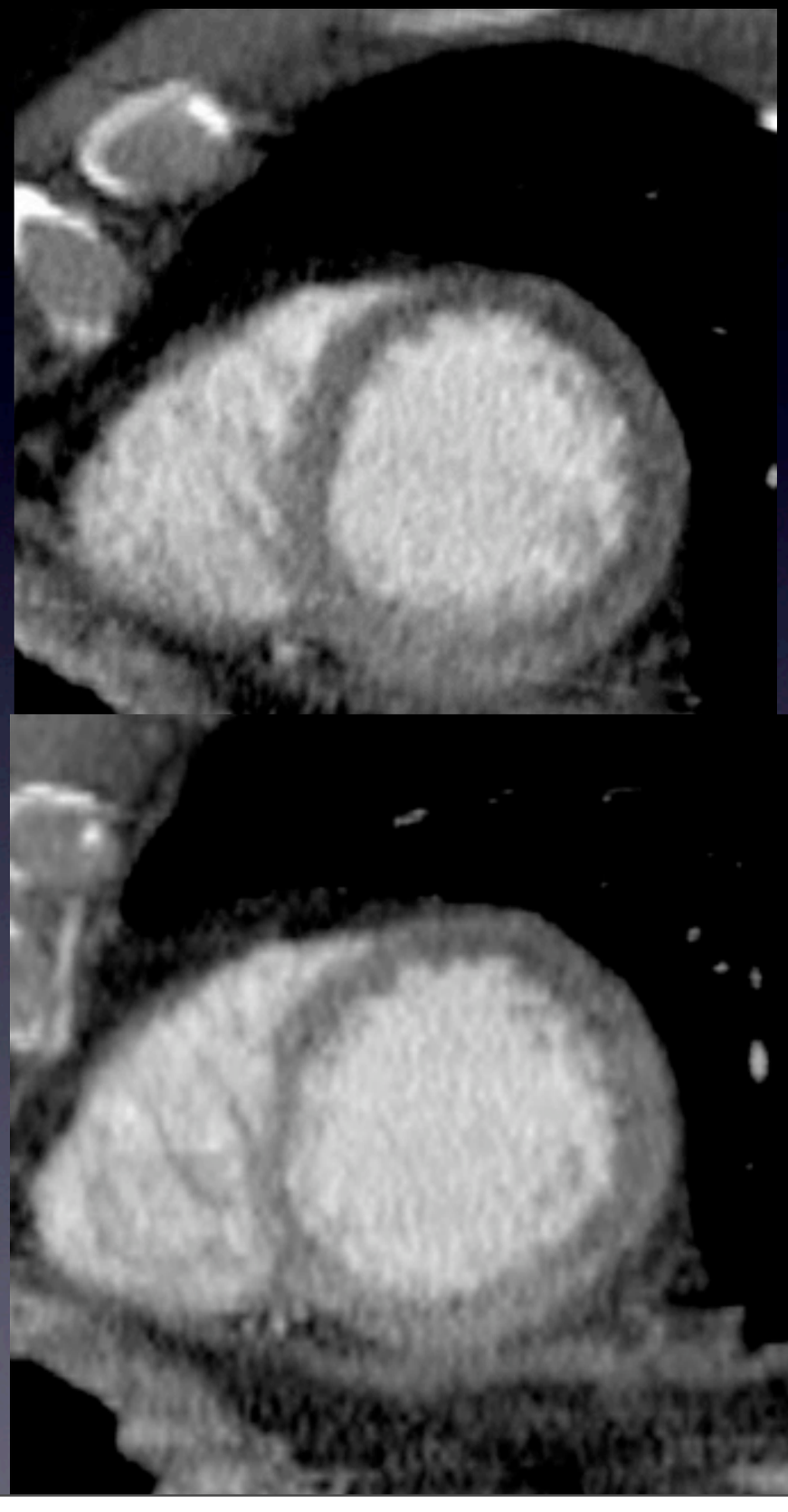


CCTA

Example: Acute CP

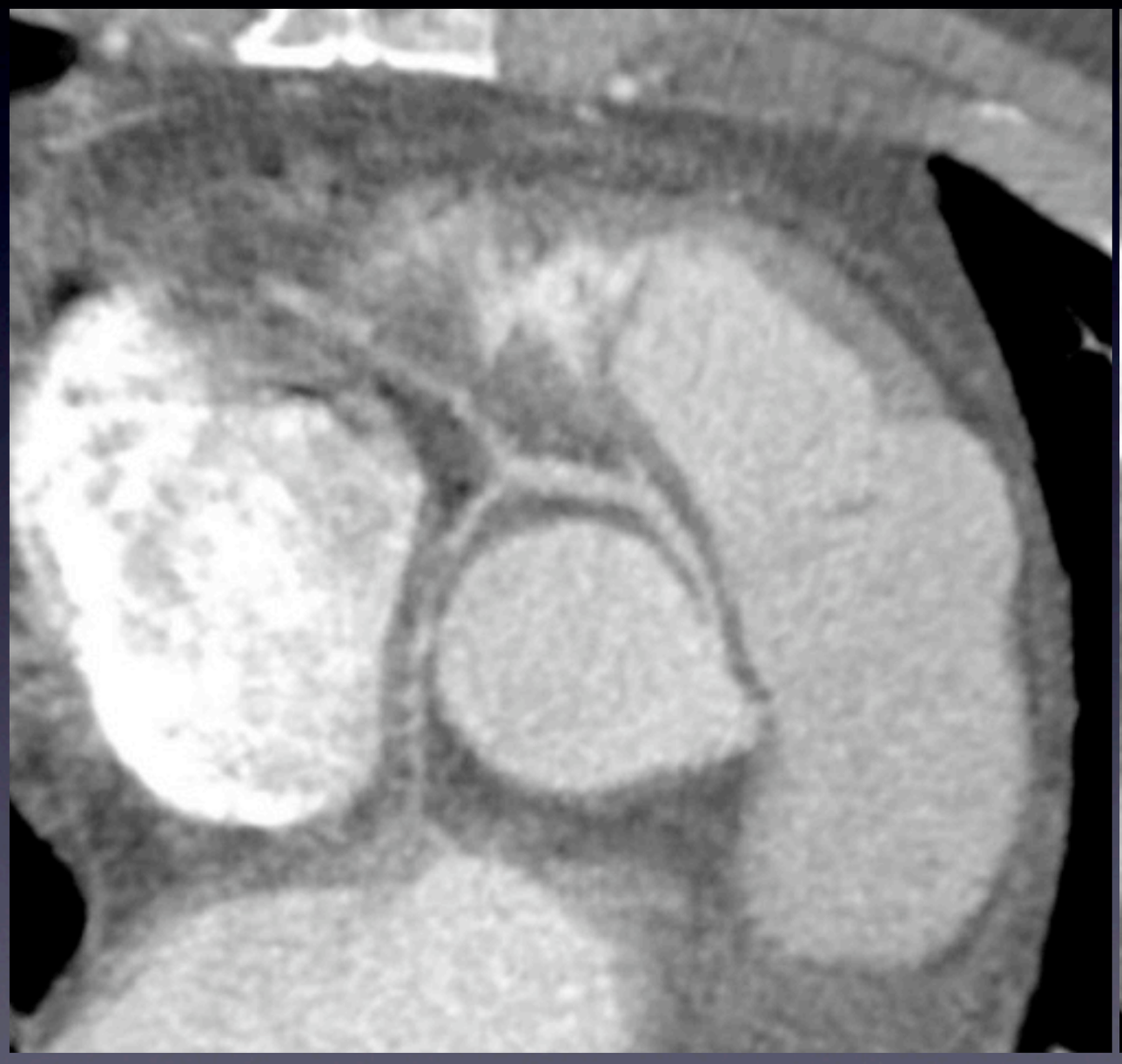


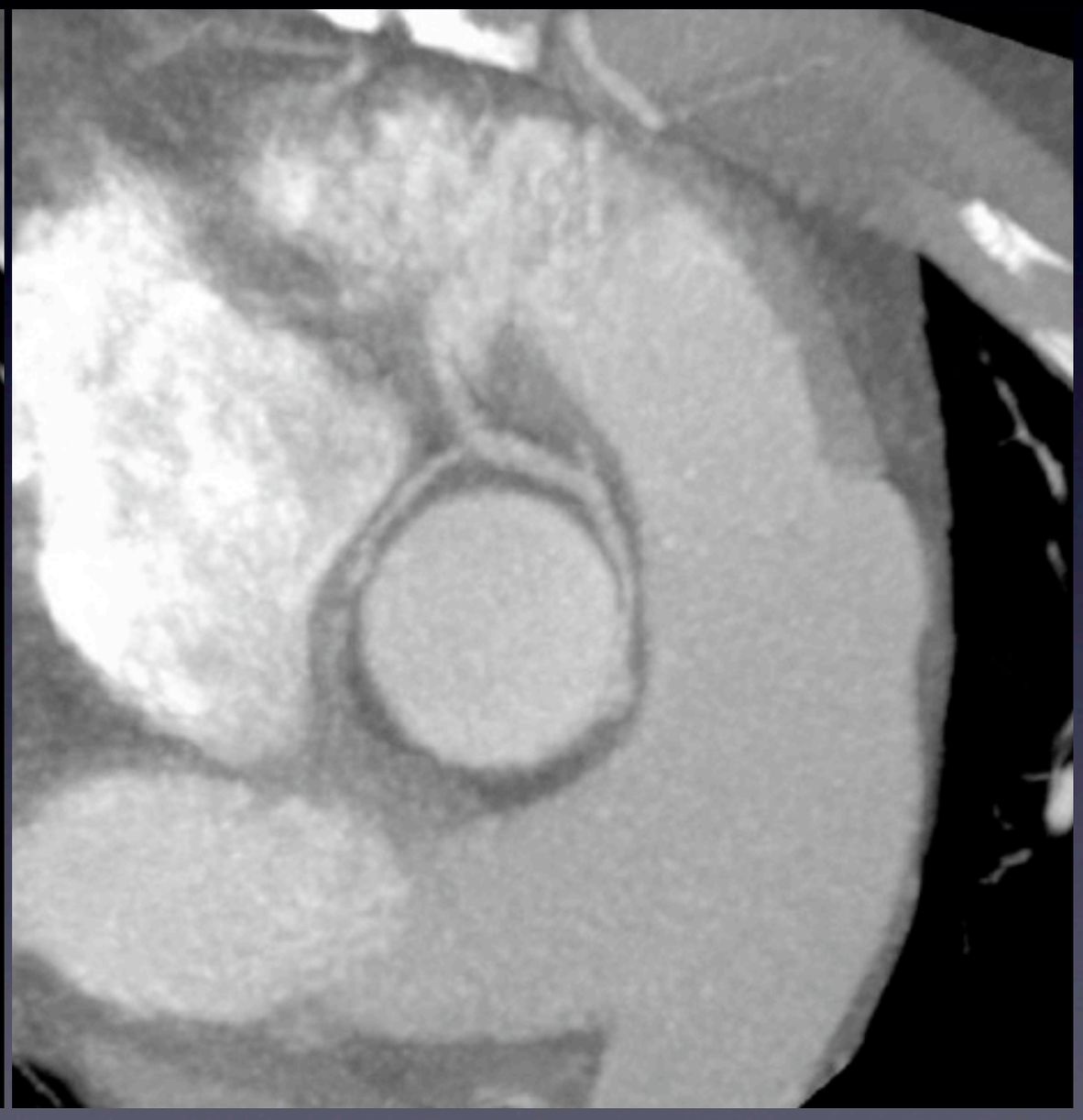




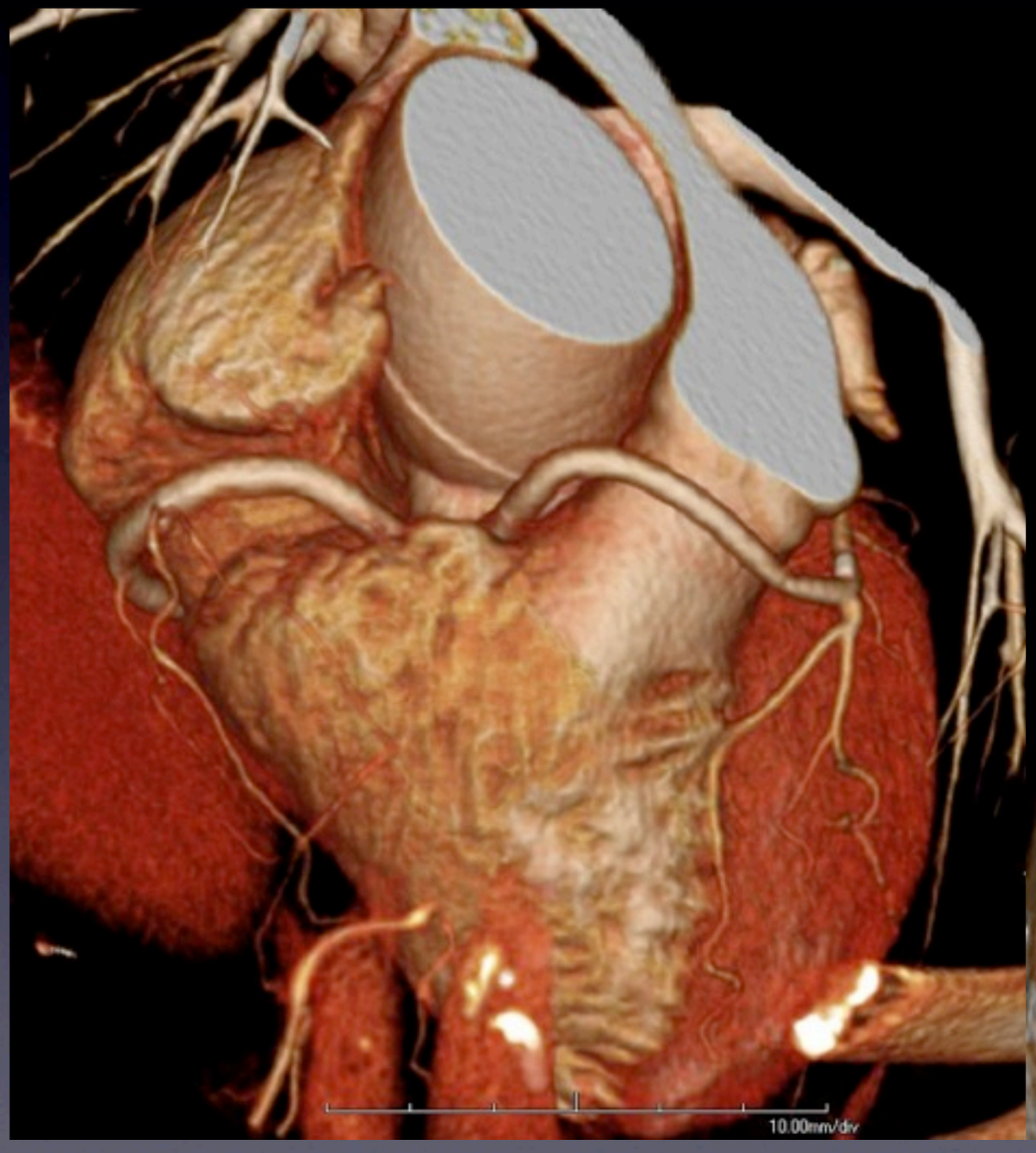
CCTA

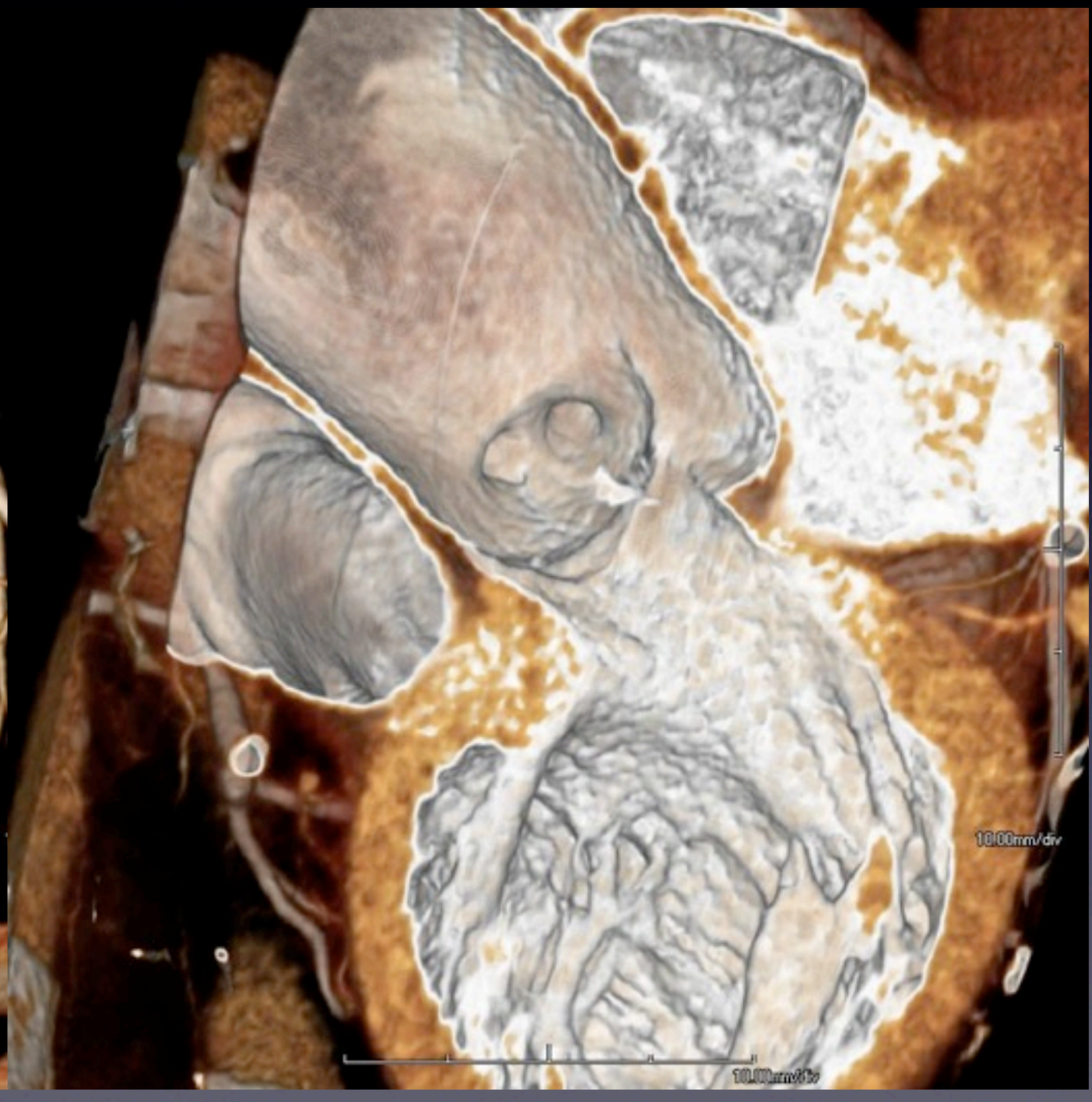
Example: "Malignant" Coronary Anomaly





Example: “Benign” Coronary Anomaly





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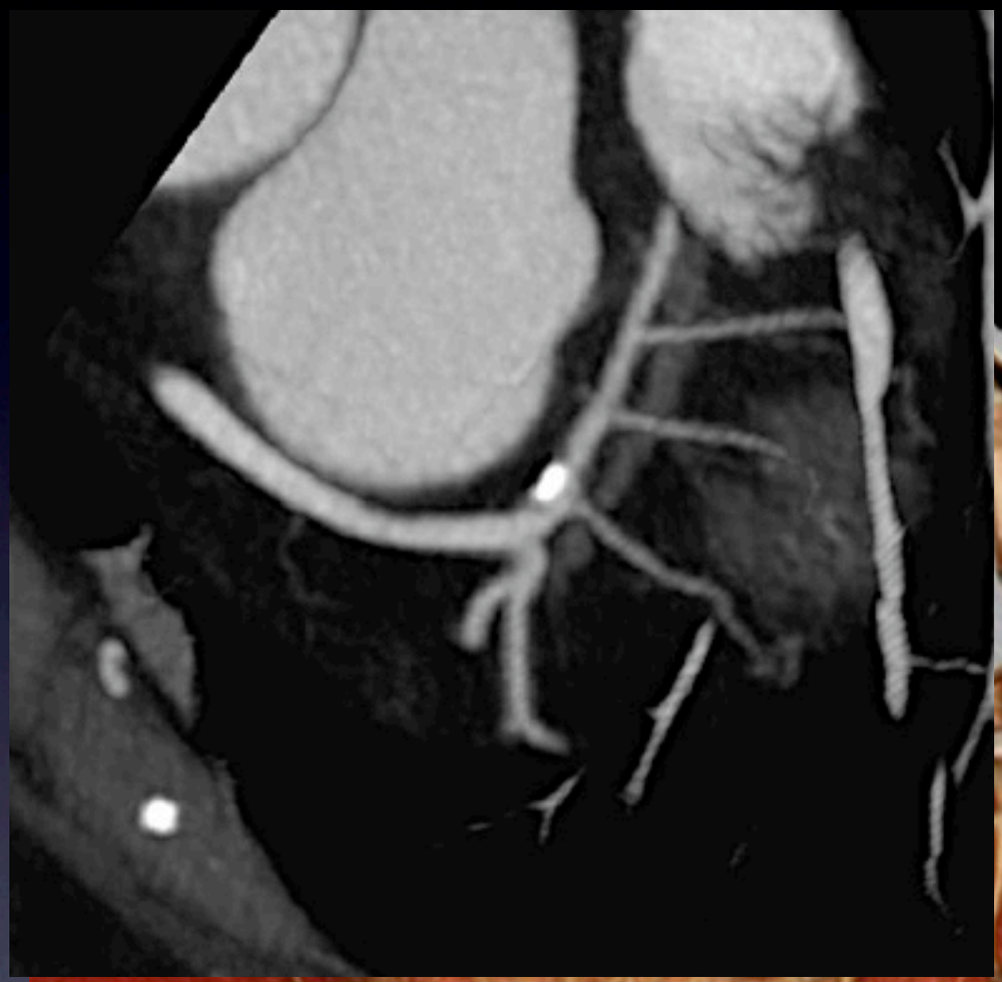

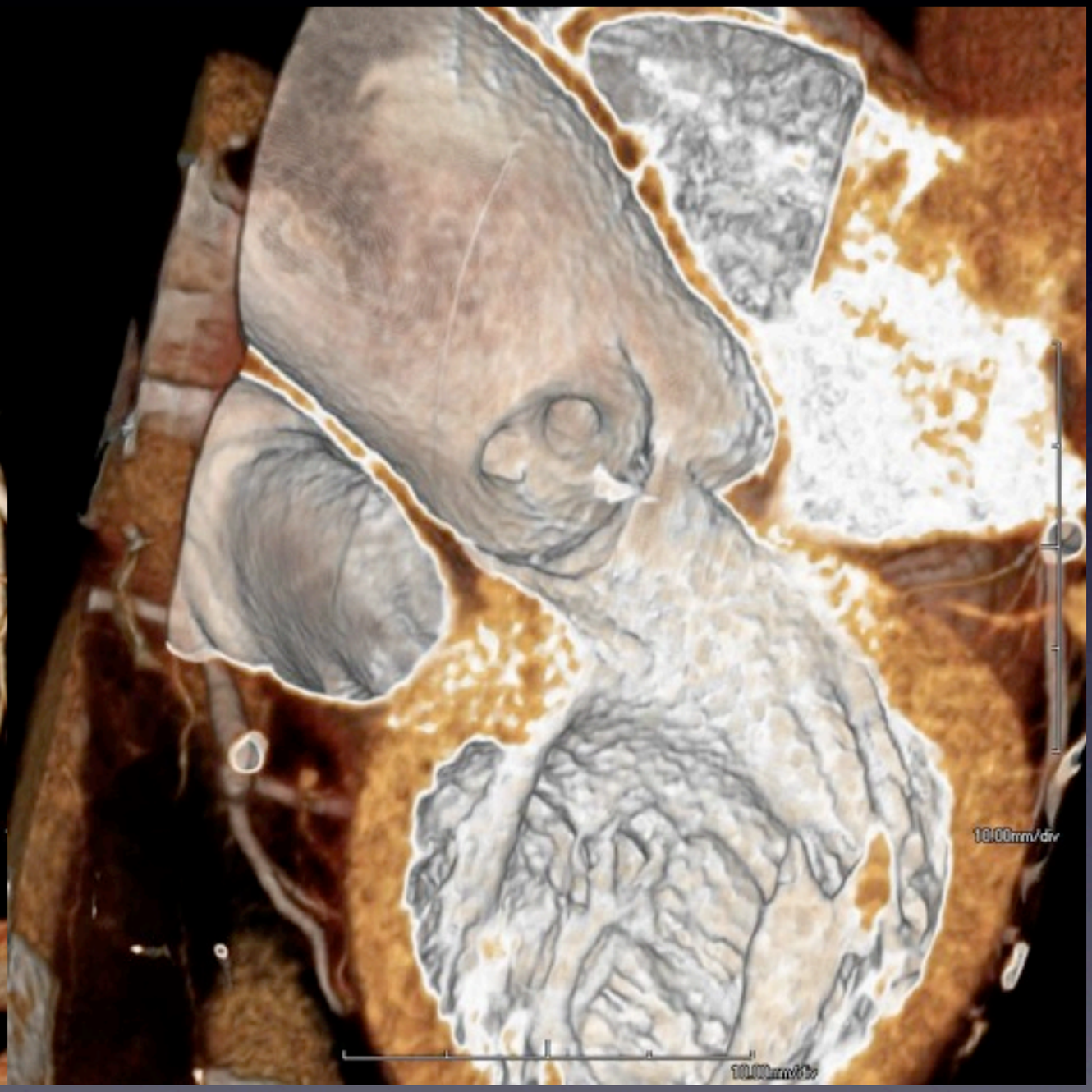

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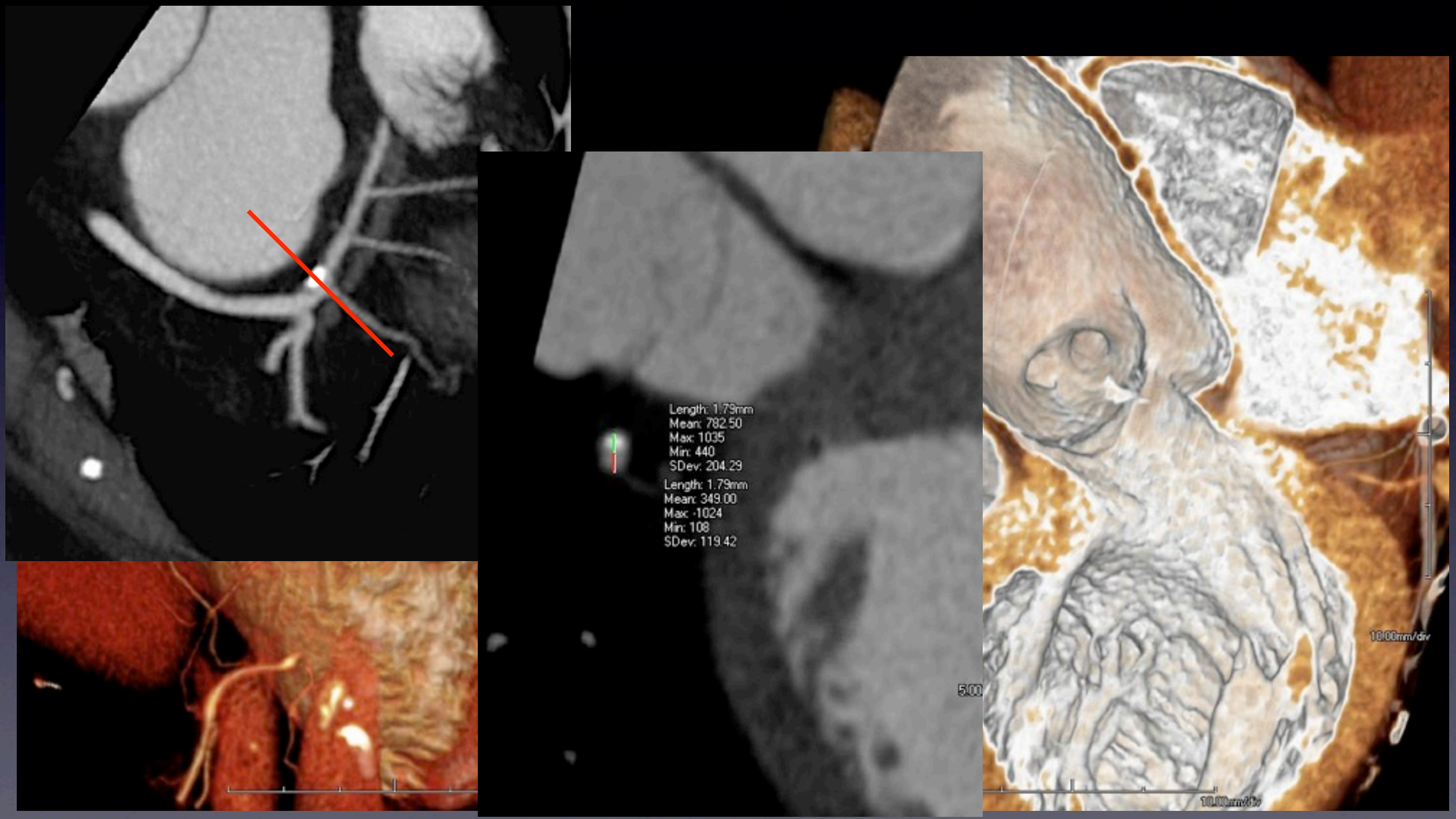
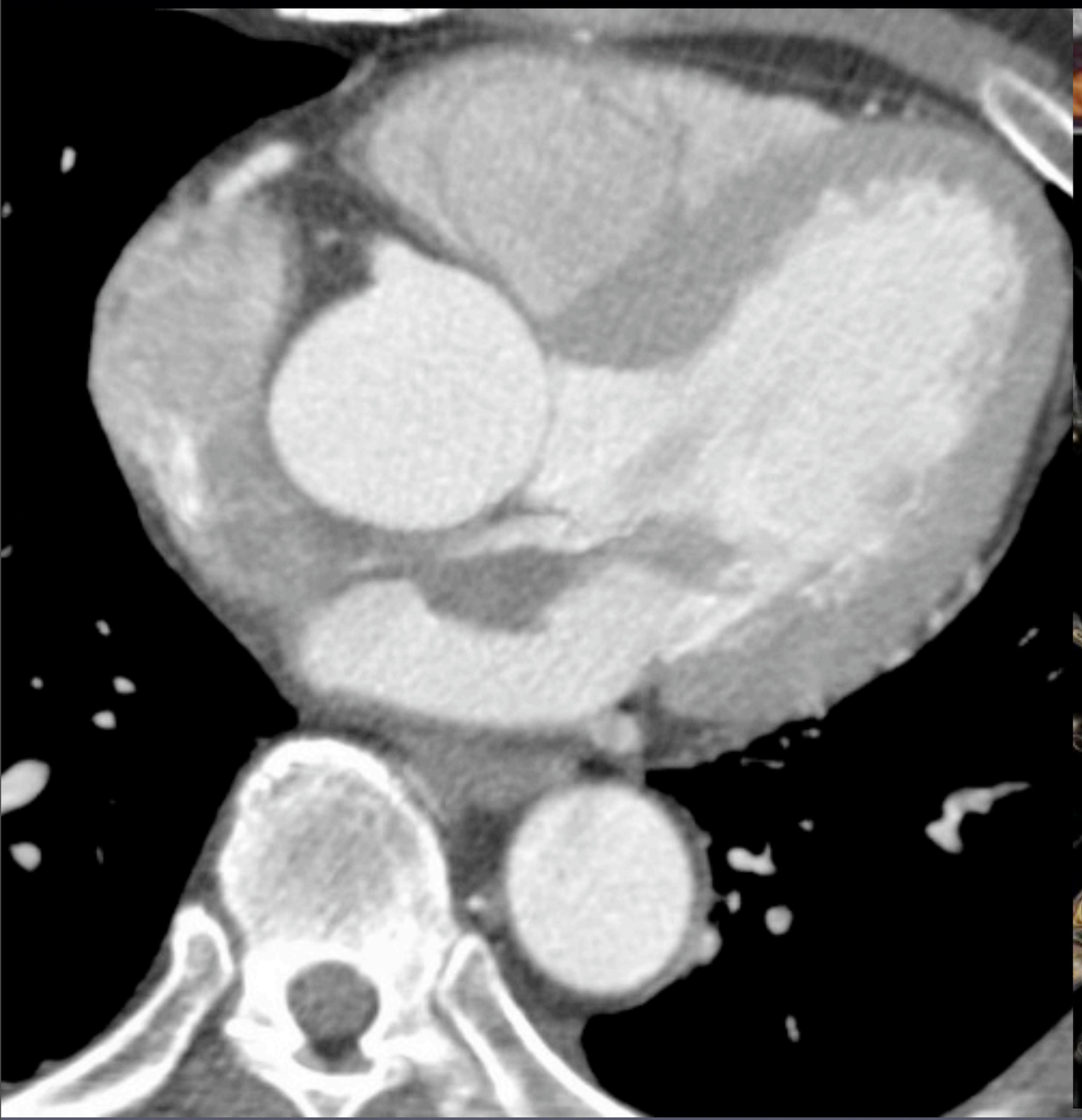
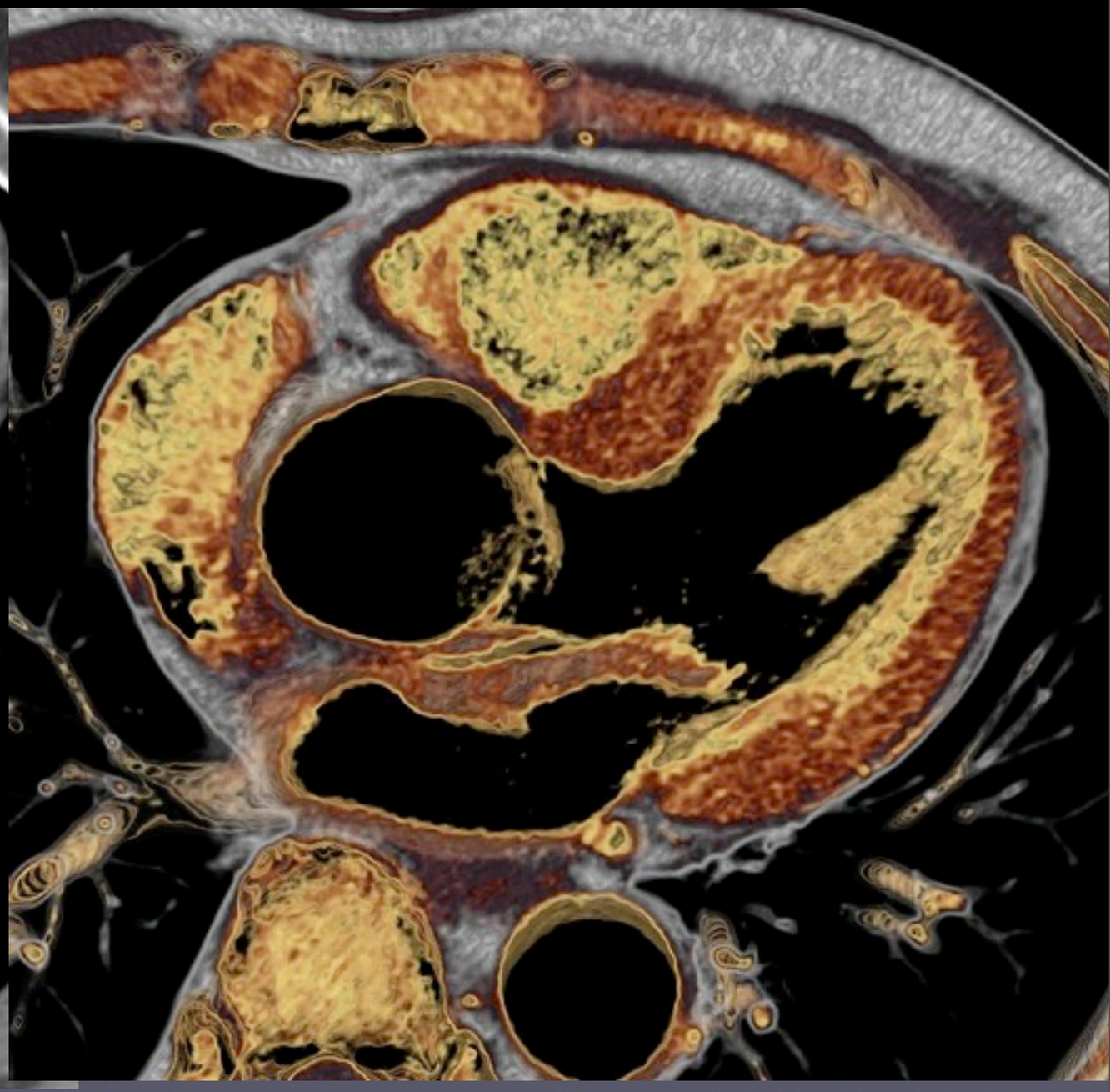


Example: Cardiac Tumor





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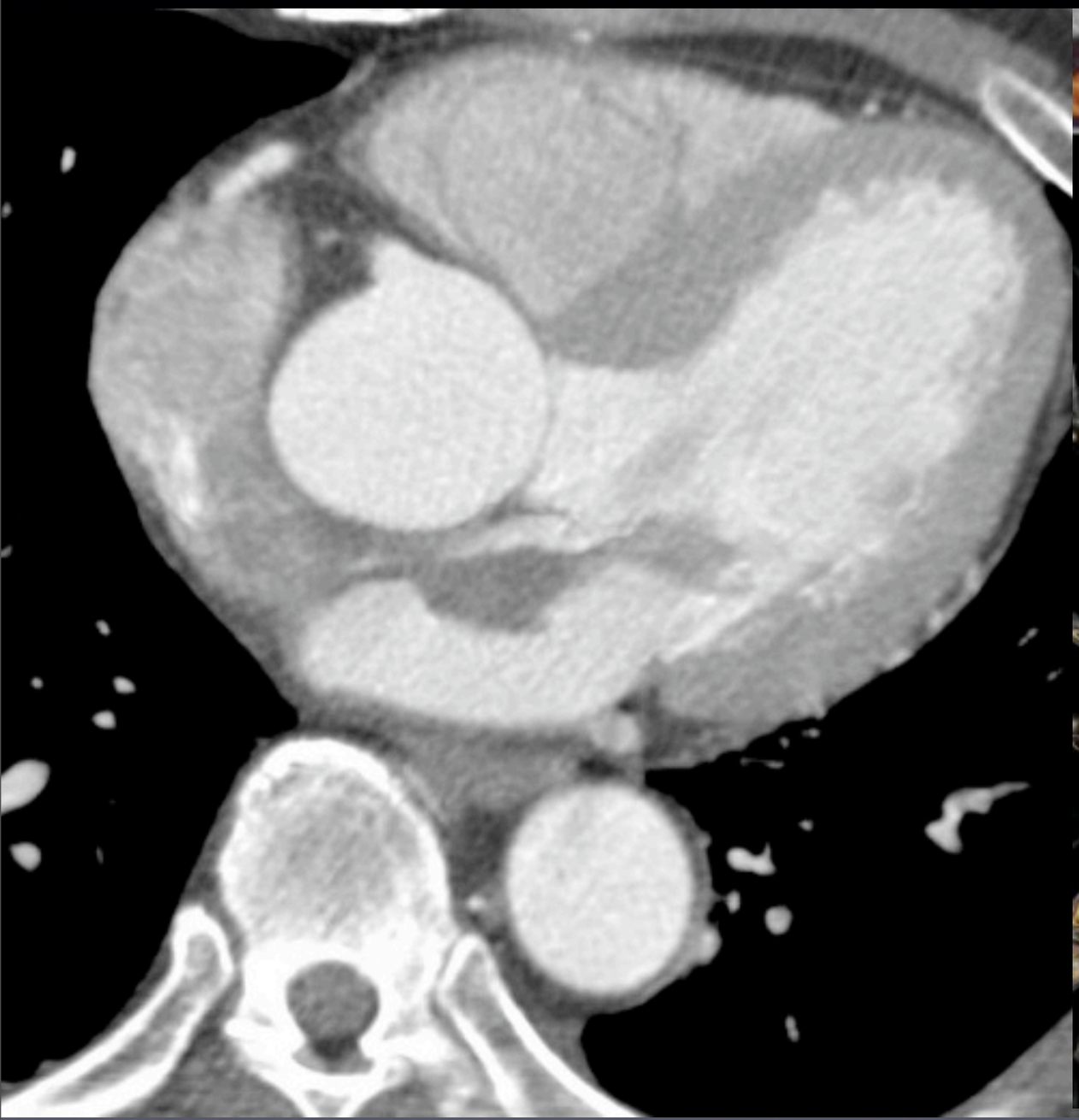

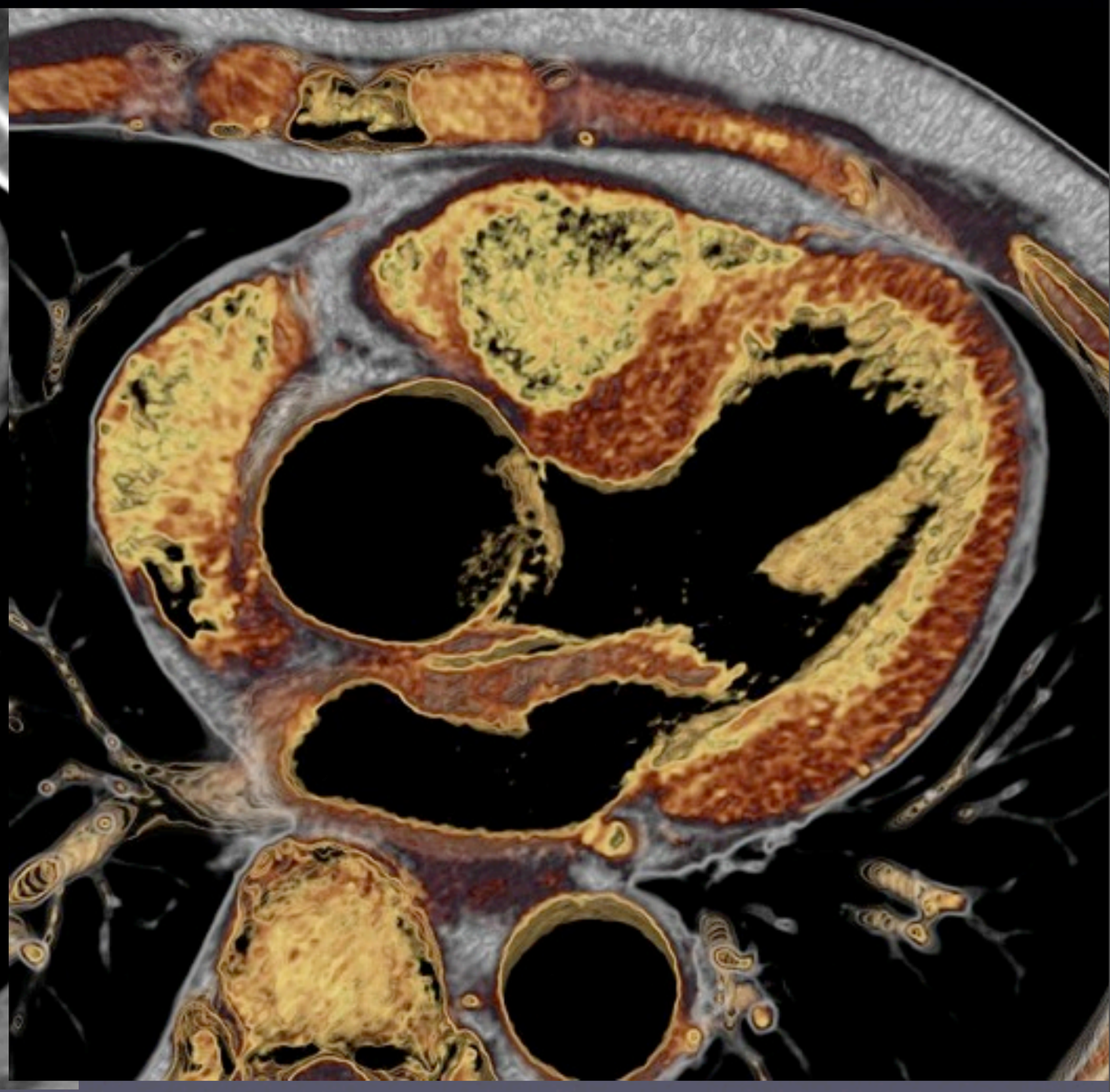

LA Myxoma


FAQ

FAQ: CAC

- What does the Calcium Score mean?
- What should one do with a calcium score of ___?

Calcium Scores mean:

- An independent and incremental prognostic value for risk stratification over Framingham risk score-based strategy alone
- If there is calcium, by definition there is CAD
- Potential refinement up or down of 10-yr risk stratification

What is risk of significant coronary stenosis at cath depending on CAC?

- Budoff (2002): 1851 Symptomatic patients
  - Range of CAC = 0 (21%) to 6649
    - Mean 380, median 116
  - 53% had obstructive disease (≥50%) at cath
  - Overall: sens = 96% spec = 40%
  - If CAC > 100: sens = 76% spec = 75%

Budoff MJ, et al.Circulation. 2002;105:1791-1796

Stenosis in patients with high CAC (MESA data)

- Had cath: CAC 528 ±772
  - Non-sig dz: 43%
  - 1 vessel dz: 23%
  - 2 vessel dz: 14%
  - 3 v / LM dz: 20%
- No Cath: CAC 136 ±399

Boaz et al. JACC Img, 2009; 2:1175-1183

Hard Cardiac Event Risk

% patients	CAC	Hazard Ratio for Cardiac Event	Annual Incidence (% per yr)
50	0	1	0.1
25	1-100	4	0.6
12	101-300	8	1.5
13	>300	10	3

Detrano AD, et al. N Engl J Med 2008, pp. 1336–1345

ALL CAUSE 10 yr. mortality

CAC SCORE	10 yr All Cause Mortality (%)
0	1 .0
1 - 10	2.0
>10	9.0

~ 44,000 patients

* 45% patients had CAC = 0

Blaha, et al.J Am Coll Cardiol Img (2009), pp. 692–700

“Negative” Calcium Score

Shareghi et SCCT 2007:

- ~ 35000 patients
- if CAC=0, annual event rate = 0.027%

Shareghi N, et al. J Cardiovasc Comput Tomogr (2007), pp. 155–159

FAQ: CAC

- What does the Calcium Score mean?
- What should one do with a calcium score of ___?

Management of CAC

CAC	10-yr risk stratification
0	very low
1-10	low
10-100	moderate
100-400	high
>400	very high

FAQ - CCTA

- Do insurances cover CCTA?
- Why is CCTA a better test than CAC?
- Does CCTA take the place of a stress test? Does CCTA stress the heart?
- Can a primary care doctor order these, or is CCTA just for cardiologists?

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Insurance Coverage

- All major insurances including Medicare and Anthem cover CCTA
  - For “appropriate” indications
- Few cover CAC (Witham discounts)

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CCTA vs. CAC

- CCTA: Usually SX patients
  - Direct visualization of coronary artery lumen and wall
  - Grade stenosis
  - Problem-solving (MPI, echo, etc)
- CAC: Usually ASX pts
  - Risk Stratification

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CCTA - Stress

- NO pharamacolgic stress (future direction)
- Complementary to MPI
- Problem-solving for equivocal MPI / stress tests

CCTA in patients w/ Stress Imaging: 2010 Consensus Appropriateness

- Normal ECG Stress Test w/ continued Sx
- Duke Treadmill Score - Intermediate risk
- Discordant stress ECG and imaging findings
- Stress Imaging results = equivocal
- Stress Imaging normal, but new or worsening Sx

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Ordering Questions

- ANY medical specialty can order CCTA
- Use Appropriate Indications (printed info)
- Call / email us
  - 765-485-8374 (Witham Reading Room)
  - xraydoc97@yahoo.com

SUMMARY:

APPROPRIATE INDICATIONS: CORONARY AND CARDIAC CT

CLINICAL SCENARIO	FOR THESE INDICATIONS:	ORDER
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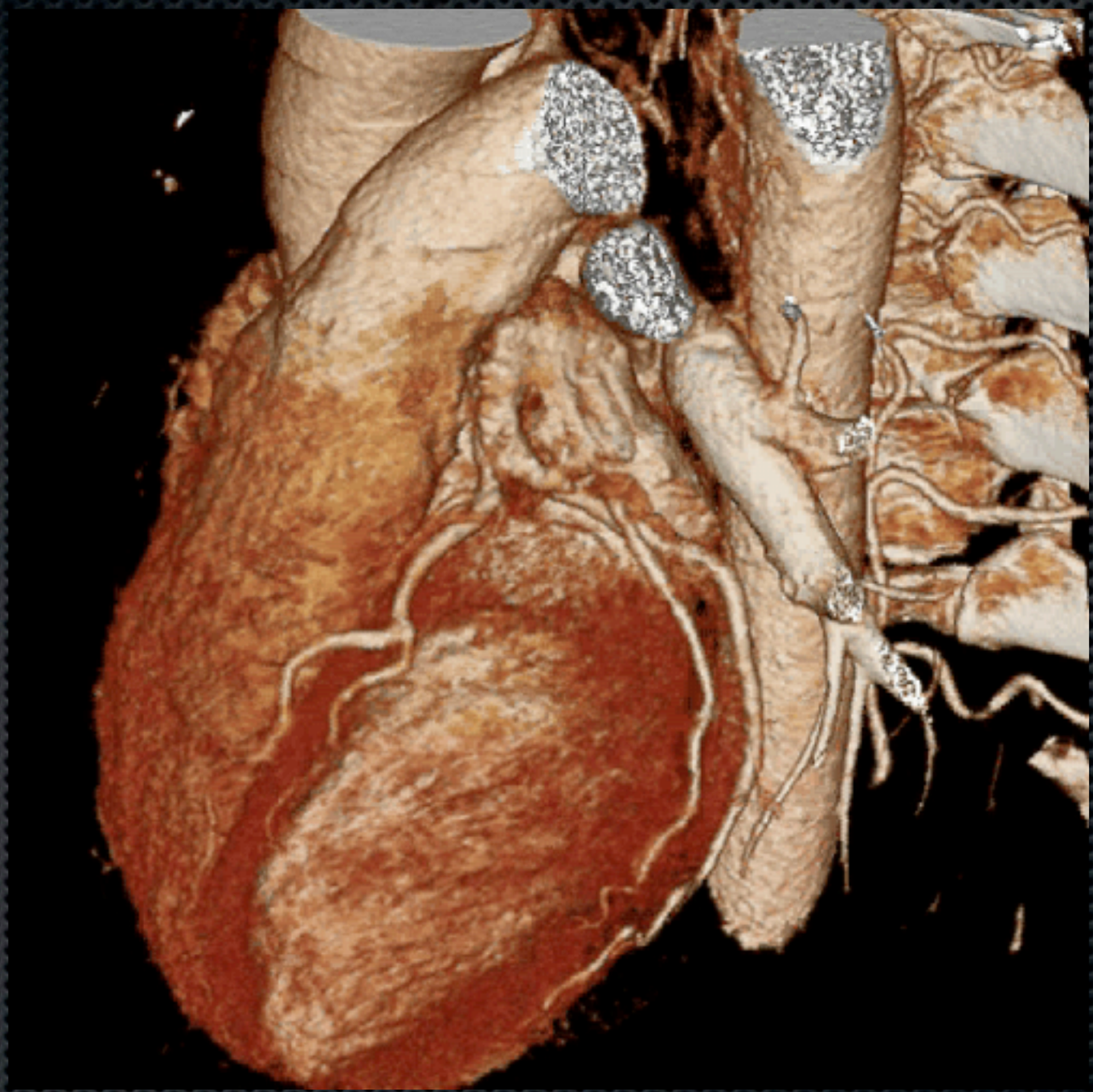
Conclusions

- CAC can help refine FRS classification for patients, especially those at intermediate risk
- Coronary CTA is a robust technique for selected ED and outpatients at low - intermediate risk by FRS
- TRO exams can be ED problem- solvers
- CCTA can save time, decrease morbidity, and save resources while providing accurate diagnostic information to direct patient care.

Thanks for your attention!!



Questions?
xraydoc97@yahoo.com

Handout:
http://stanford.edu/~hallett