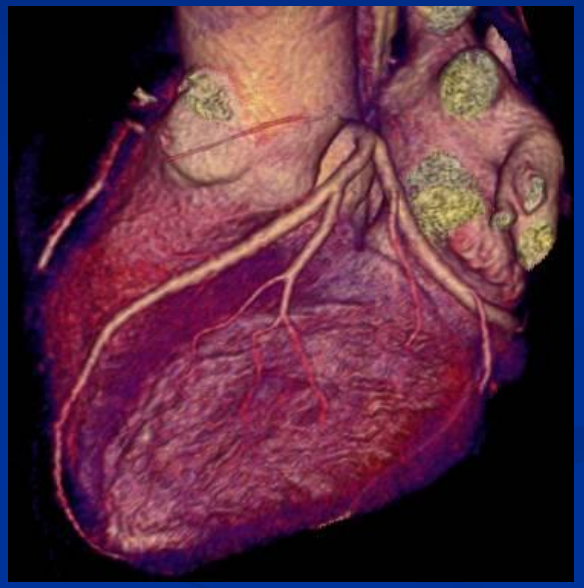
CARDIAC CTA



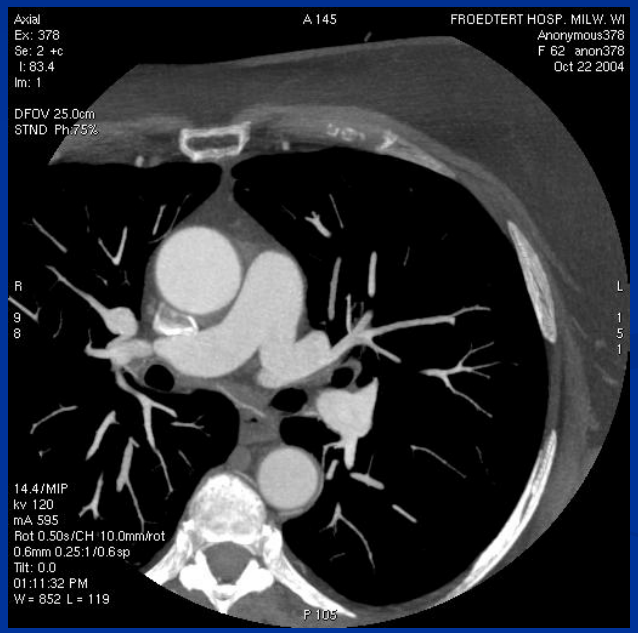
Michael Elliott, MD

Cardiac CTA

11/7/2009

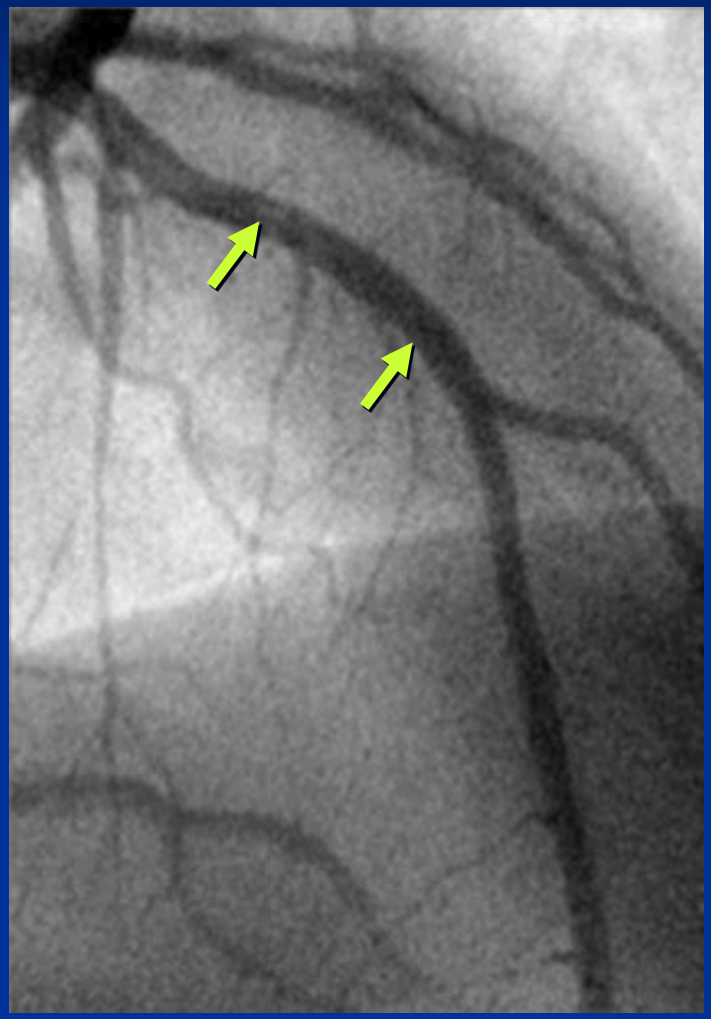
MDCT Coronary Angiography

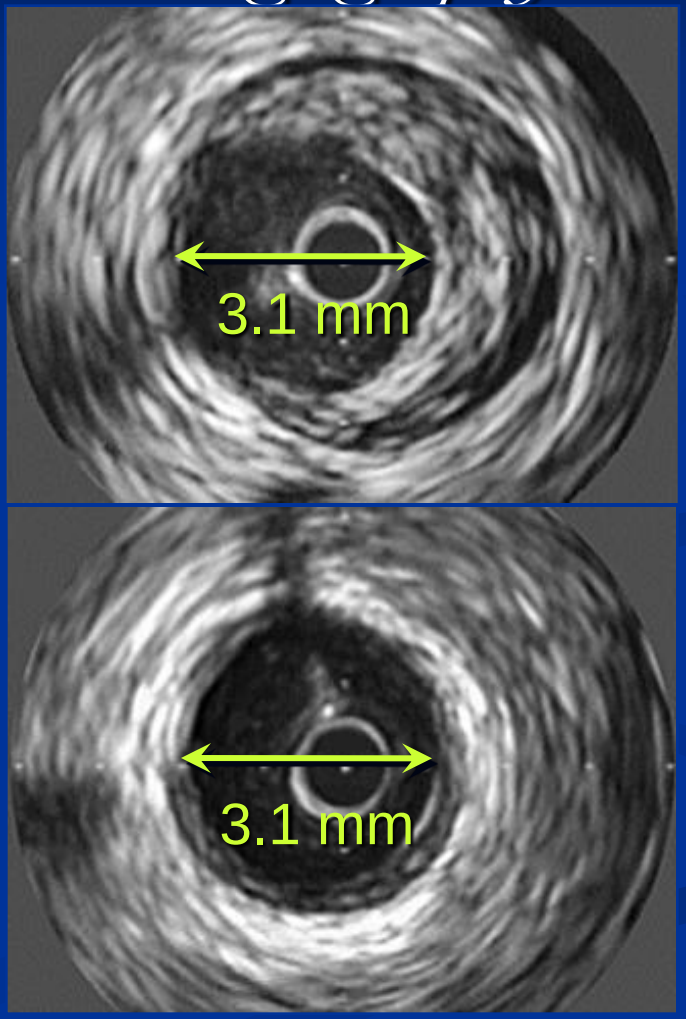
Image Reconstruction



Vascular Imaging

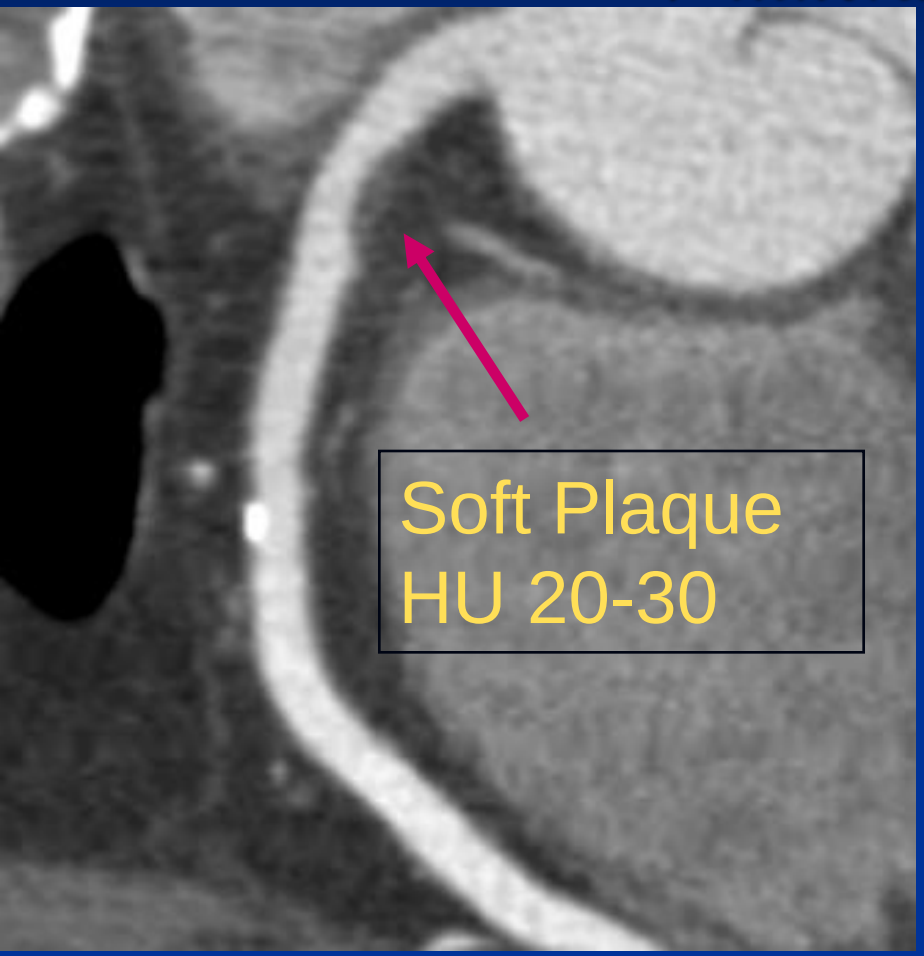
Limitations to Invasive Angiography

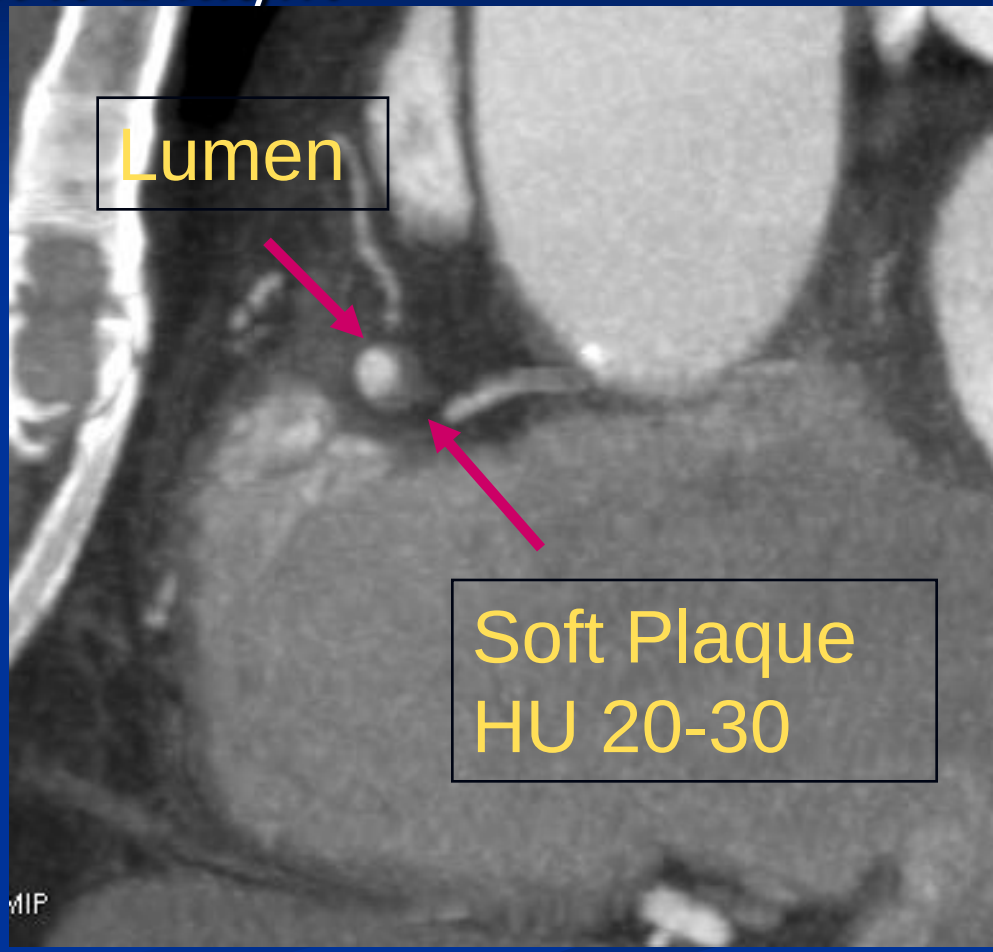




Vessel Wall Imaging With MDCT

Vulnerable Plaque





Vessel Wall Imaging With MDCT

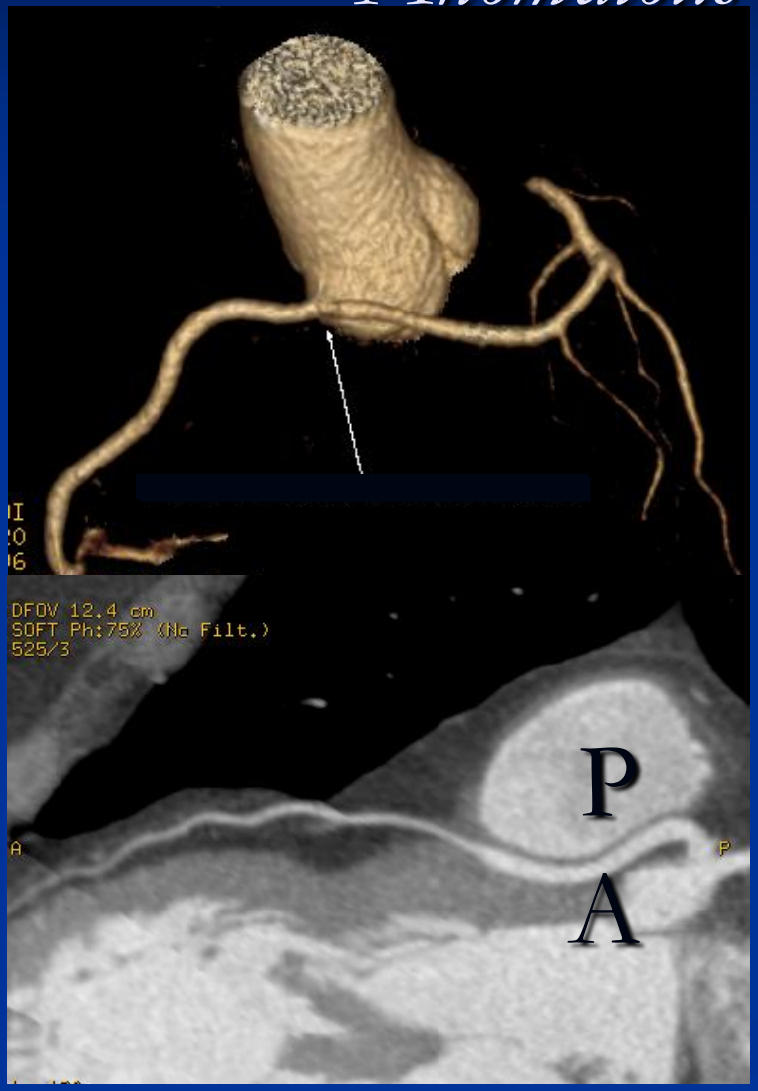
Differential Plaque Composition

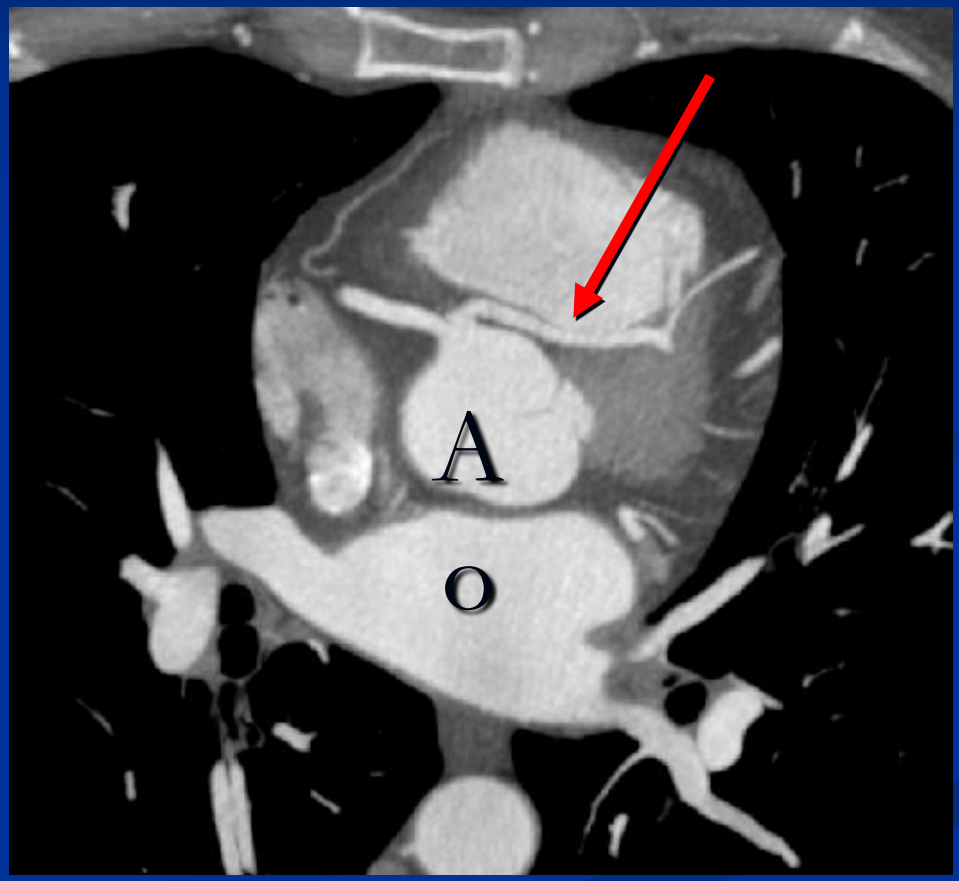
Thrombus	0-15 HU
Lipid	15-30 HU
Fibrous	30-75 HU
Calcium	130-500 HU

WHAT ARE THE CURRENT CLINICAL APPLICATIONS?

Complex Coronary Anatomy

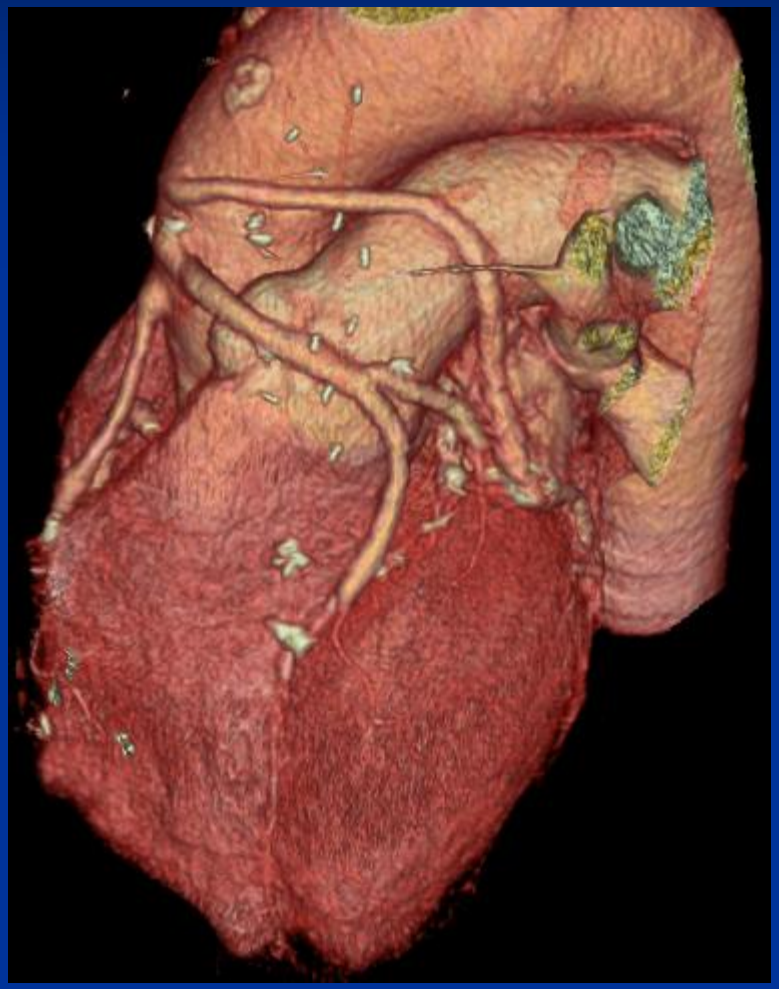
Anomalous Coronary Artery

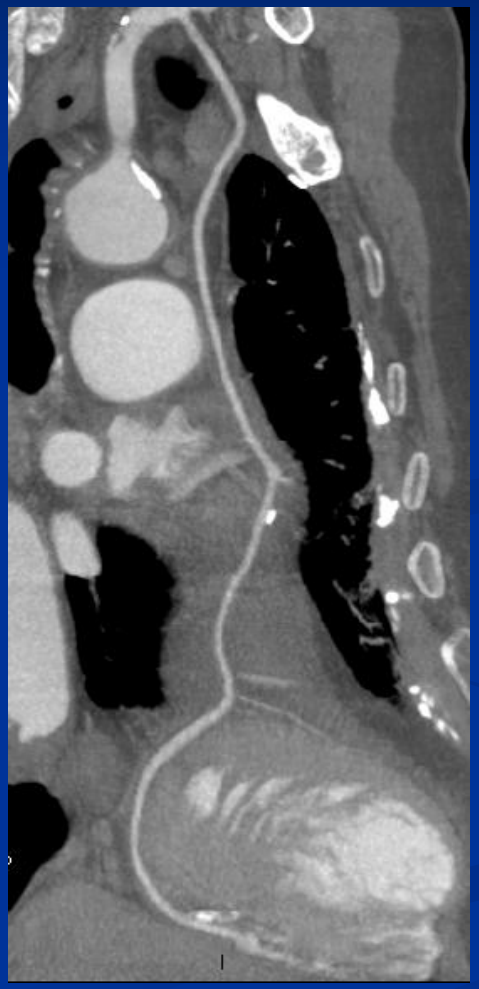




Coronary Artery Bypass Grafts

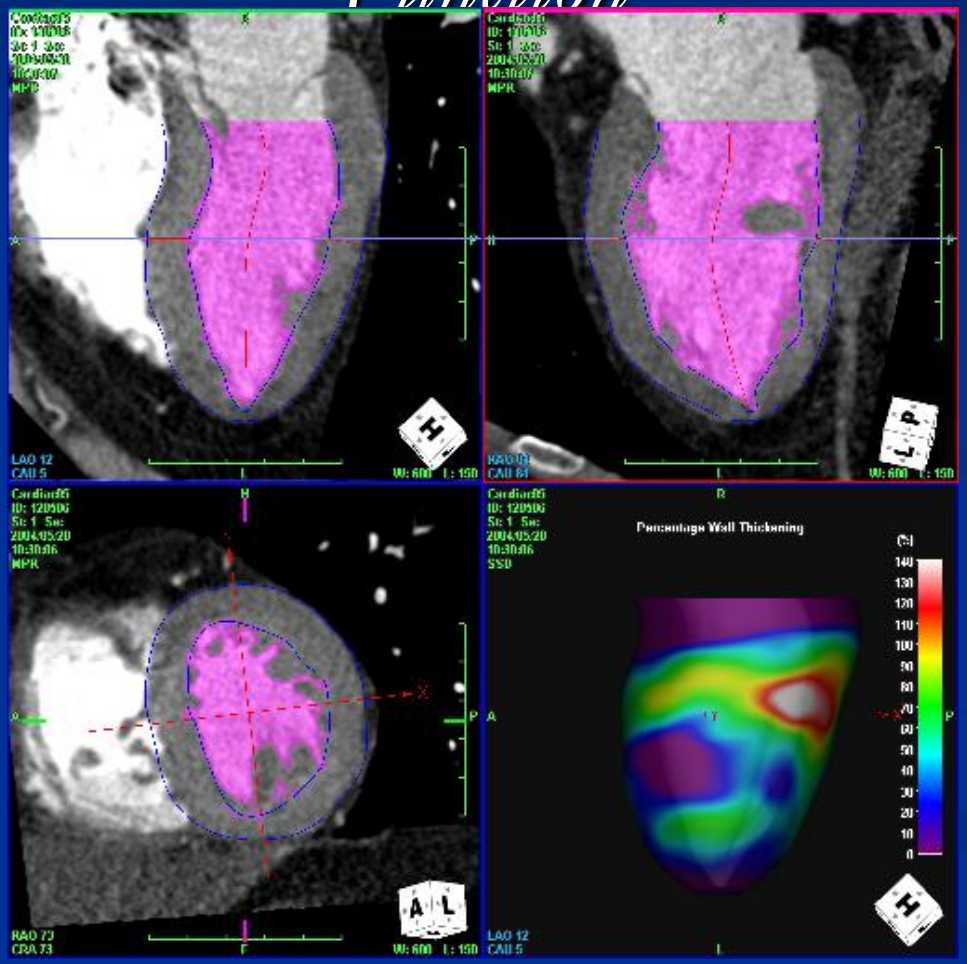
Stenosis Severity & Anatomic Course





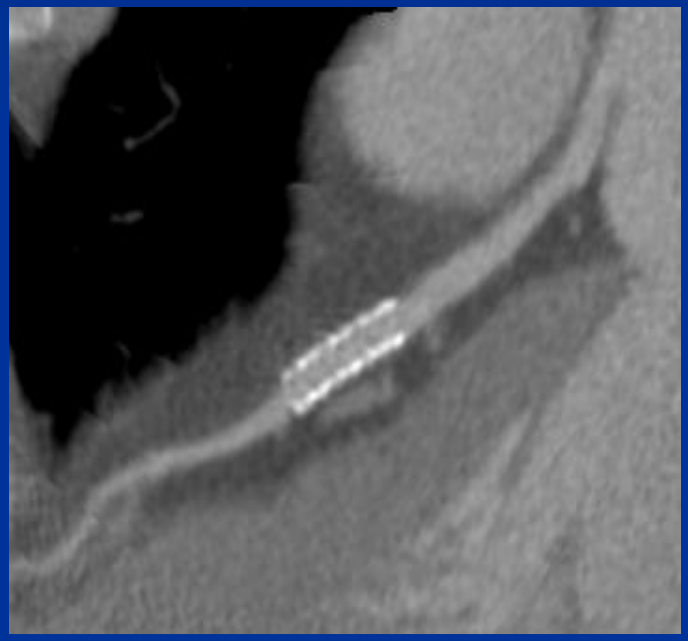
Cardiac MDCT

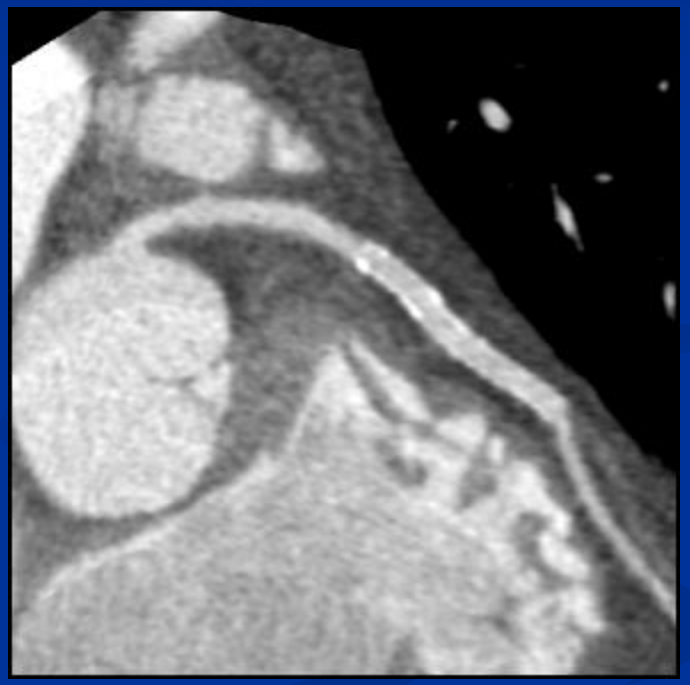
Non-Coronary Applications – Ventricular Function



MDCT Assessment

In-Stent Restenosis





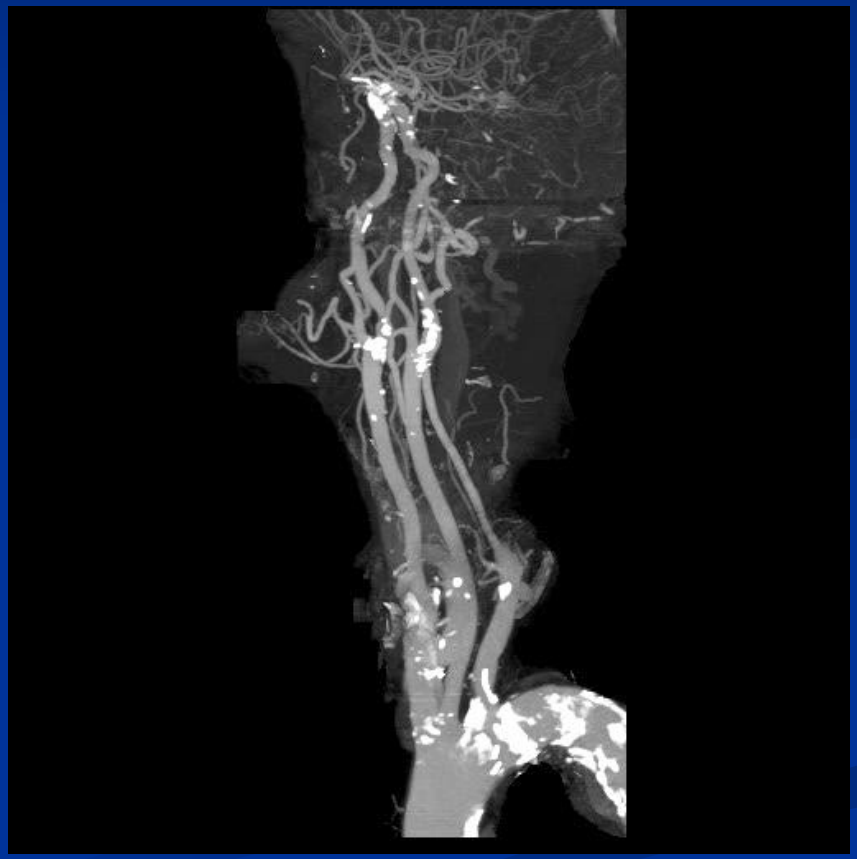
MDCT Assessment Of In-Stent Restenosis

Taxus Express 2 2.5 mm

Liberte 3.5 mm

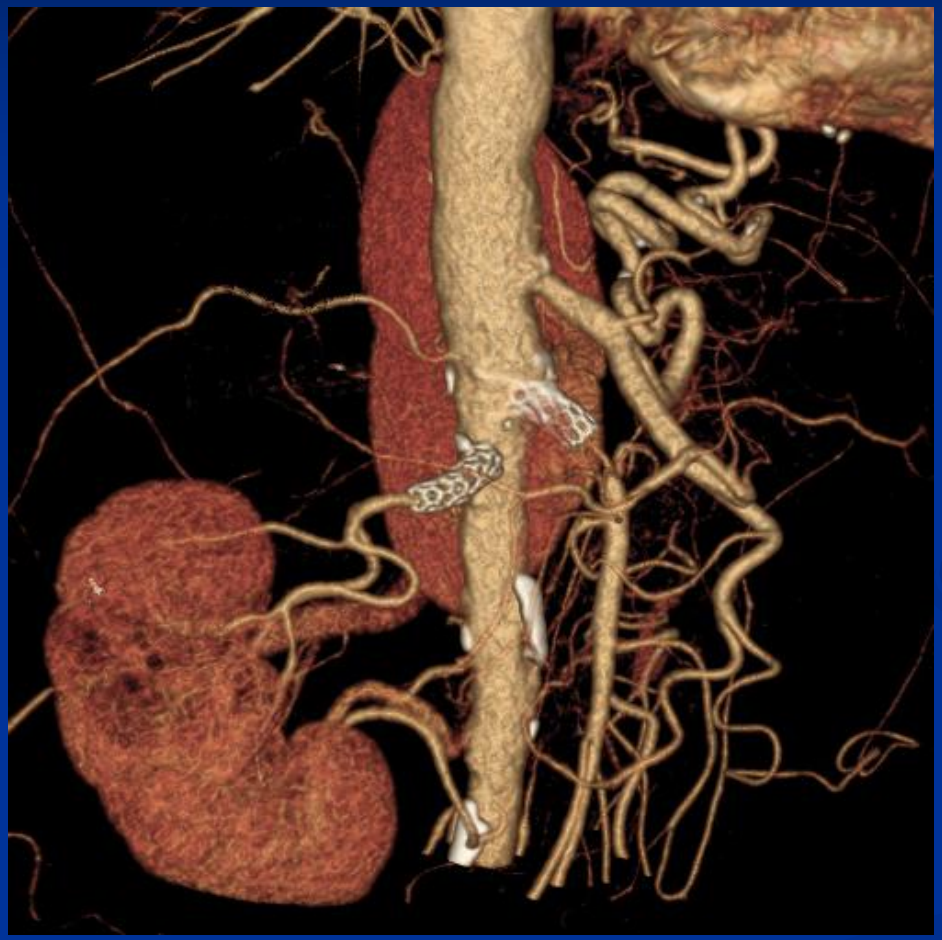
Non-Coronary Vascular Imaging

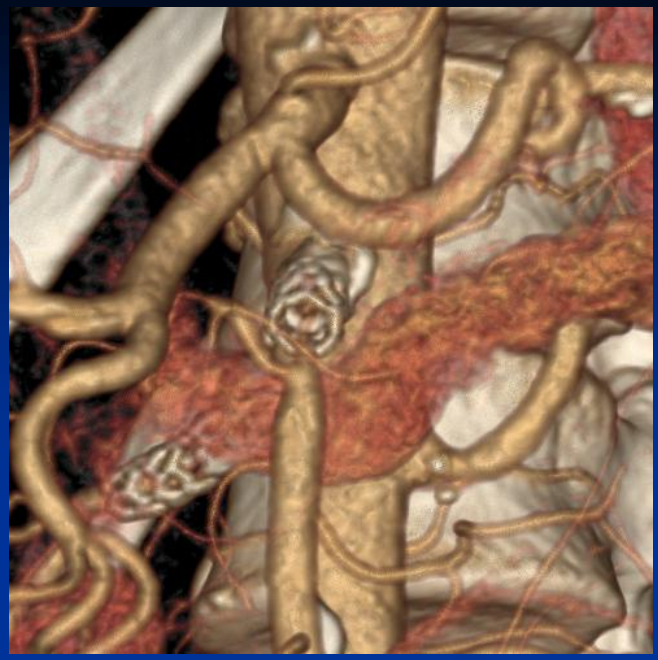
Arch, Great Vessels, Cerebral Angiography



MDCT Imaging

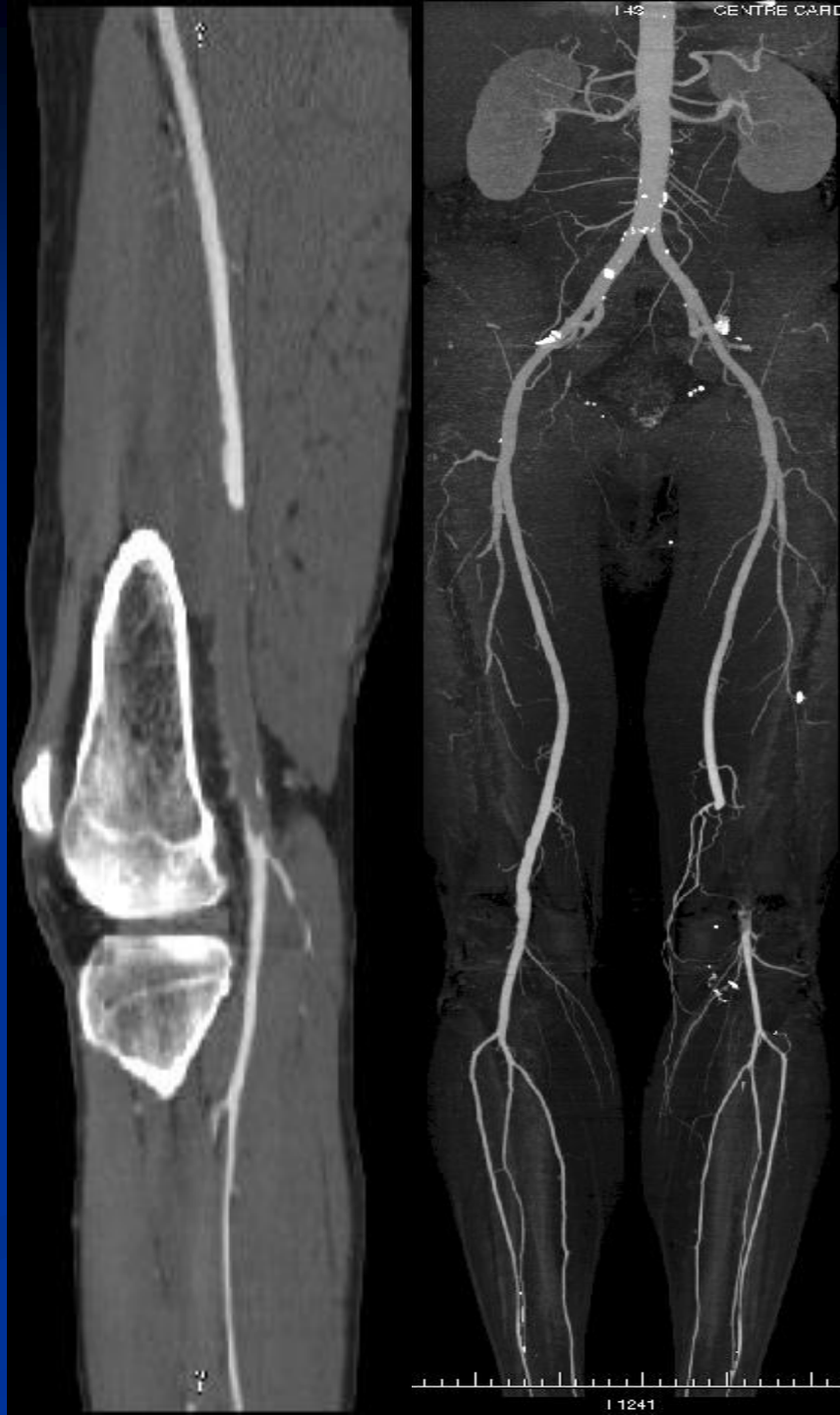
Mesenteric & Renal Artery





MDCT Imaging

Popliteal Artery Thrombosis



MDCT - Cardiac

Emergency Room Chest Pain

- Tremendous Potential
- Rapid, accurate assessment of ED chest pain with non-diagnostic ECG and normal troponin

MDCT - Cardiac

Emergency Room Chest Pain

- 12 million ED chest pain eval/yr
- Common source of litigation for ED MDs
- Numerous/varied CP triage strategies

MDCT Coronary Angiography

- Acute chest pain sestamibi trials
- 20-25% reduction in hospital admits
- MDs frustrated by lack of specificity with acute sestamibi perfusion imaging

MDCT Coronary Angiography

Diagnostic Studies

- Meta-analysis of 27 diagnostic studies (16/64) JACC 2006;48:1896-1910
- Per-Pt analysis: Sensitivity-**96**%, Specificity-**74**%
- Limitations: Small studies (mean 73 pts)
  --excluded unassessable segments
  --limited vessel size (> 1.5 mm)
  --excluded pts with high HR, Ca++, obese
  --High prevalence of known CAD

MDCT Coronary Angiography

Diagnostic Studies

- CORE-64 study*: Multi-center study of 291 pts over age 40 scheduled for x-ray coronary angiography
- 85% sensitivity--90% specificity for detection of obstructive CAD

*N Engl J Med 2008;359:2324-36

MDCT Coronary Angiography

Diagnostic Studies

- Excluded nearly 30% of pts from analysis--primarily due to high calcium score

* N Engl J Med 2008;359:2324-36

MDCT Coronary Angiography

Chest pain in ED

- Absolutely need a strategy (imaging) with high sensitivity and specificity
- Safe strategy

MDCT Coronary Angiography

Diagnostic studies

- 360 symptomatic pts (age 50-70)

--No patients were excluded due to CA++

- 88% Sensitivity—90% specificity

--47% positive predictive value

--47% specificity for high CA++

--65% sensitivity for vessels ≤2.0 mm

Meijboom WB et al. J Am Coll Cardiol 2008;52;2135-2144

Multi-Row Detector CT Angiography

Major Advances Since 2000

- Spatial resolution
  - More detectors – better detail!
  - Coronary size (5mm to <1mm)
  - Current resolution 0.5-0.6 mm
- Temporal resolution
  - Faster gantry speed (330 ms)

Multi-Row Detector CT Angiography

Major Advances Since 2000

- Contrast resolution
  - Vessel lumen, calcium, low density fat
- Gating/Triggering

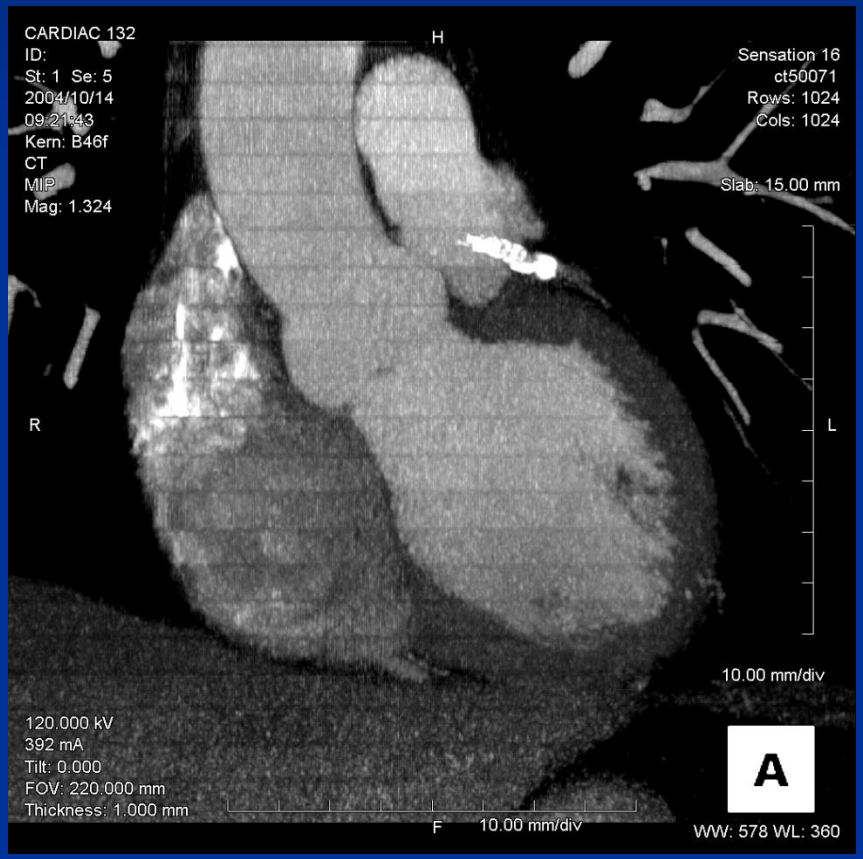
MDCT - Cardiac

Clinical Limitations

- Heart rate
  - Ideal < 60 bpm
  - REGULAR RHYTHM!
- Patient motion - Misregistration
  - Arrhythmia
  - Breathing
  - Positioning

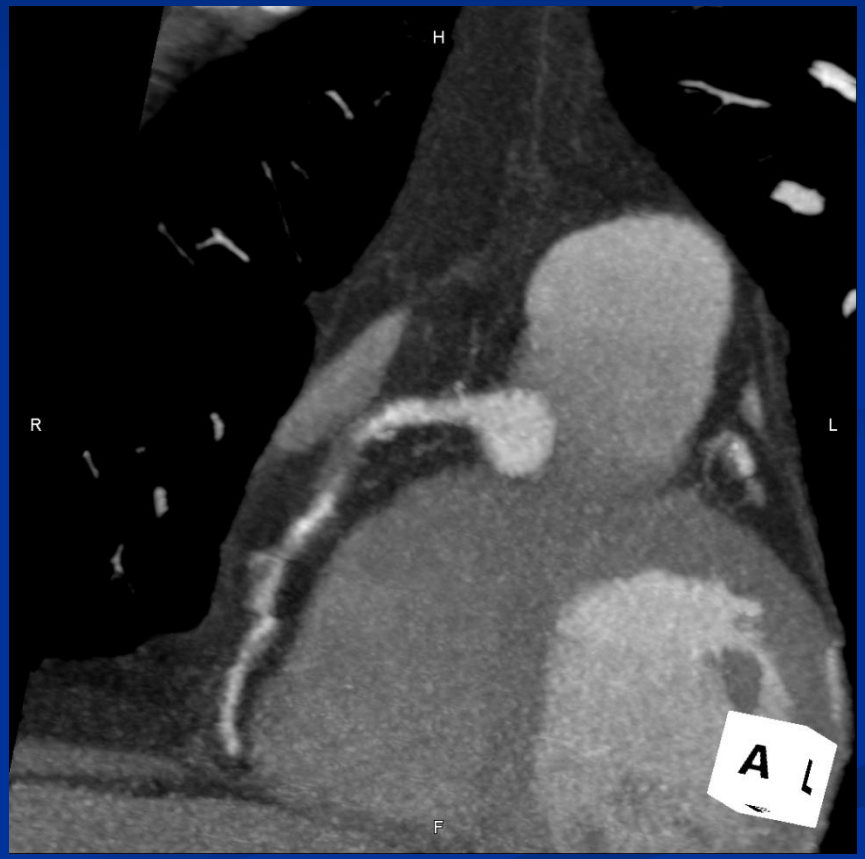
Clinical Limitations

Misregistration Illustration



Clinical Limitations

Misregistration Illustration



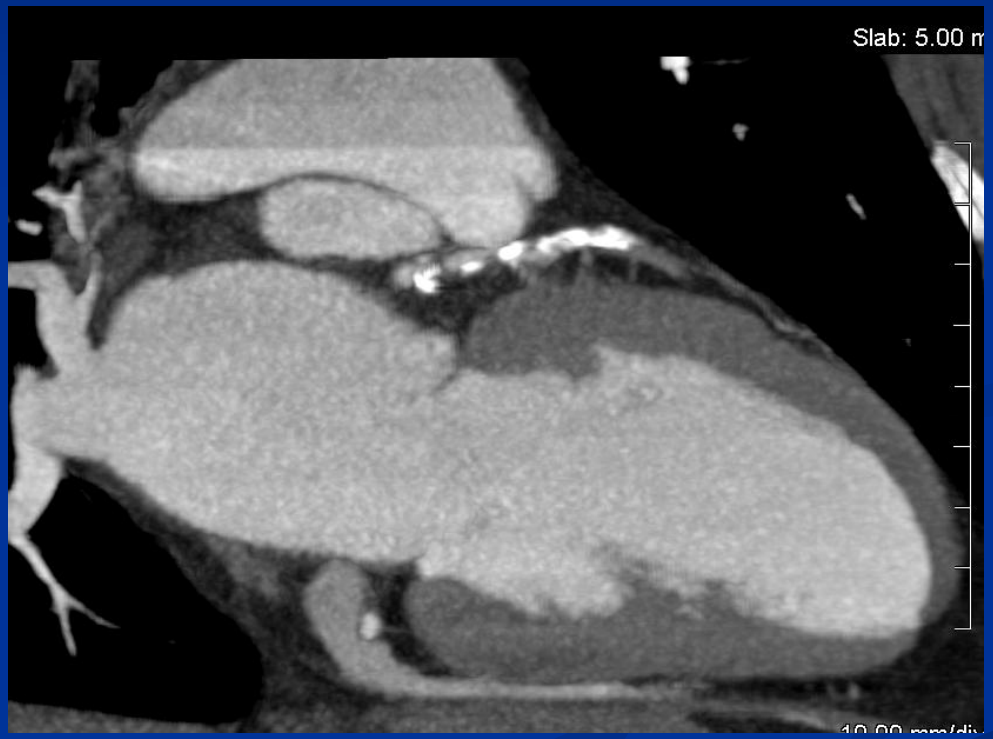
MDCT - Cardiac

Clinical Limitations

- Calcium
  - Partial volume artifacts—overestimation of lesion severity

Vessel Wall Imaging With MDCT

Rocks of Calcium…



MDCT - Cardiac

Clinical Limitations

- Ionizing radiation

--12-18 msv for 64 single source CTA

--3-5 msv for coronary angiography

--10 msv Sestamibi Nuclear stress

--27 msv for Thallium Nuclear stress

- Contrast—potential nephrotoxicity in patients with renal insufficiency

MDCT - Cardiac

Clinical Limitations-Radiation

- No large epidemiologic studies of cancer risks associated CT scans
- Extrapolated from survivors of the atomic bomb in Japan (5-150 msv)

MDCT - Cardiac

Clinical Limitations-Radiation

- 62 million CT scans per year in the US
- 1.5 to 2% of all cancers may be attributable to radiation from CT scans*

*N Engl J Med 2007;357:2277-84

MDCT - Cardiac

Clinical Limitations-Radiation

- Lifetime attributable risk of cancer associated with 64 slice coronary CT*
- 20 yr woman: 1 cardiac CT study
  1 in 143 for breast cancer

*JAMA 2007;298(3):317-323

MDCT - Cardiac

Payor Limitations

- Indiana Medicare: LCD for coronary CTA--10/06

- Commercial Payors: evolving

+ United Health Care, Sagamore, Cigna

- Anthem-BCBS, Aetna

MDCT - Cardiac

Clinical Indications (For Reimbursement in Indiana)

MEDICARE

- For Emergency Department evaluation of patients presenting with chest pain **and** the patient has been evaluated by a cardiologist

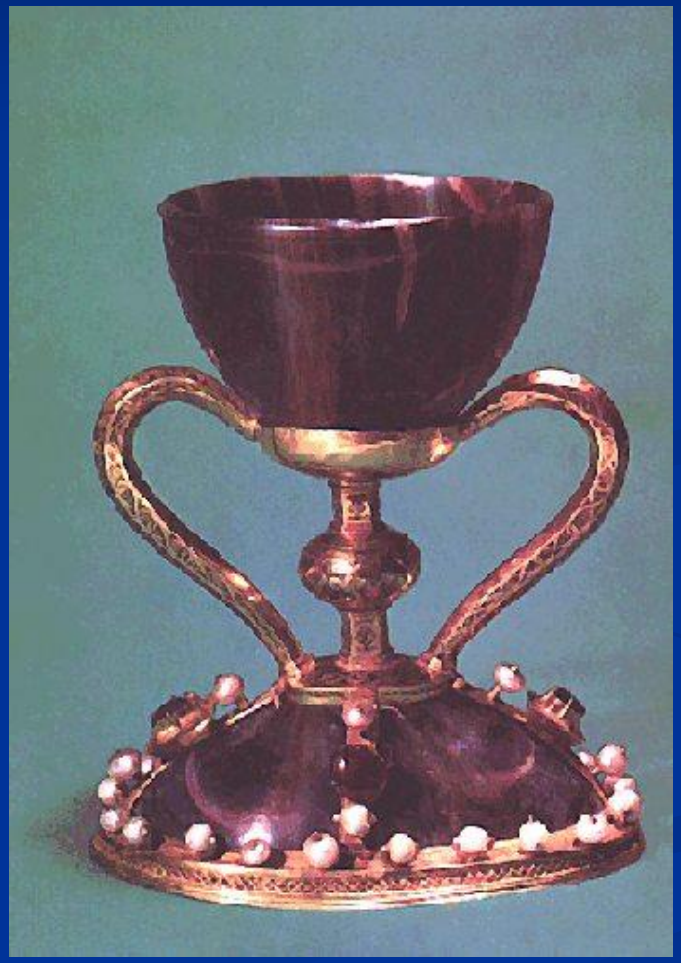
MDCT - Cardiac

Clinical Limitations-Who should not have a coronary CTA?

- Irregular rhythm
- Resting tachycardia or intolerant of b-blockers
- Renal insufficiency (creatinine >1.8, GFR <30)
- Very obese pts (BMI >40 kg/m2)
- Pts that cannot hold still or follow breathing instructions

MDCT Coronary Angiography

Have We Found The Holy Grail?



MDCT Coronary Angiography 64 slice

- NOT YET……However,
- *Ready for prime time* for specific patient groups

- 2010: This discussion may be very different

MDCT - Cardiac

Clinical Indications

ACC Appropriateness guidelines for CTA

JACC 2006 48 (7) 1475-97

- **Chest pain syndrome**
  Intermediate probability of CAD
  ECG abnormal **OR** unable to exercise

- **Equivocal stress test**
- **Suspected coronary anomalies**

MDCT - Cardiac

Beyond 64 slice: What's Next?

- CT-STAT

  750 ED chest pain pts scanned with 64 cardiac CTA

  Length of hospital stay, costs

MDCT - Cardiac

Beyond 64 slice: What's Next?

- 256, 320 detectors —increasing number of slices results in larger coverage--reducing scan time to as short as one heart beat

- Dual Source -2 x-ray tubes/detector rows
  Temporal resolution is increased 2x
  (165—83 ms)

MDCT - Cardiac

Beyond 64 slice: What's Next?

- Promise of the technological improvements:

1. Better, more consistent image quality
2. Higher heart rate imaging
3. Lower radiation (3 msv)
4. Less contrast

MDCT - Cardiac

Clinical Indications (For Reimbursement in Indiana)

- **Chest pain syndrome**
  - In lieu of an imaging stress test
- **Equivocal stress test**

Screening? 

MDCT - Cardiac

Clinical Indications (For Reimbursement in Indiana)

- New or recurrent symptoms in patients with known CAD
- Assess CABG bypass or coronary artery stent patency/stenoses

MDCT - Cardiac

Clinical Indications (For Reimbursement in Indiana)

- 64 CTA is **NOT** an optimal test for pts with chronic CAD, s/p CABG/PCI

MDCT - Cardiac

Clinical Indications (For Reimbursement in Indiana)

Electrophysiology

- Pulmonary veins prior to RFA for AFIB
- Cardiac veins prior to Bi-V lead for CRT

MDCT - Cardiac

Clinical Indications

2002 ACC/AHA criteria for probability of CAD

Intermediate probability of CAD

--15%-85% of obstructive CAD

1. Any female 30-50 with typical Sx
2. Any female >50 with atypical Sx

MDCT - Cardiac

Clinical Indications

2002 ACC/AHA criteria for probability of CAD

Intermediate probability of CAD

1. Any male 30-40 with typical or atypical Sx
2. Any male >40 with atypical or non-anginal Sx

MDCT - Cardiac

Other appropriate clinical indications

ACC Appropriateness guidelines for CTA

JACC 2006 48 (7) 1475-97

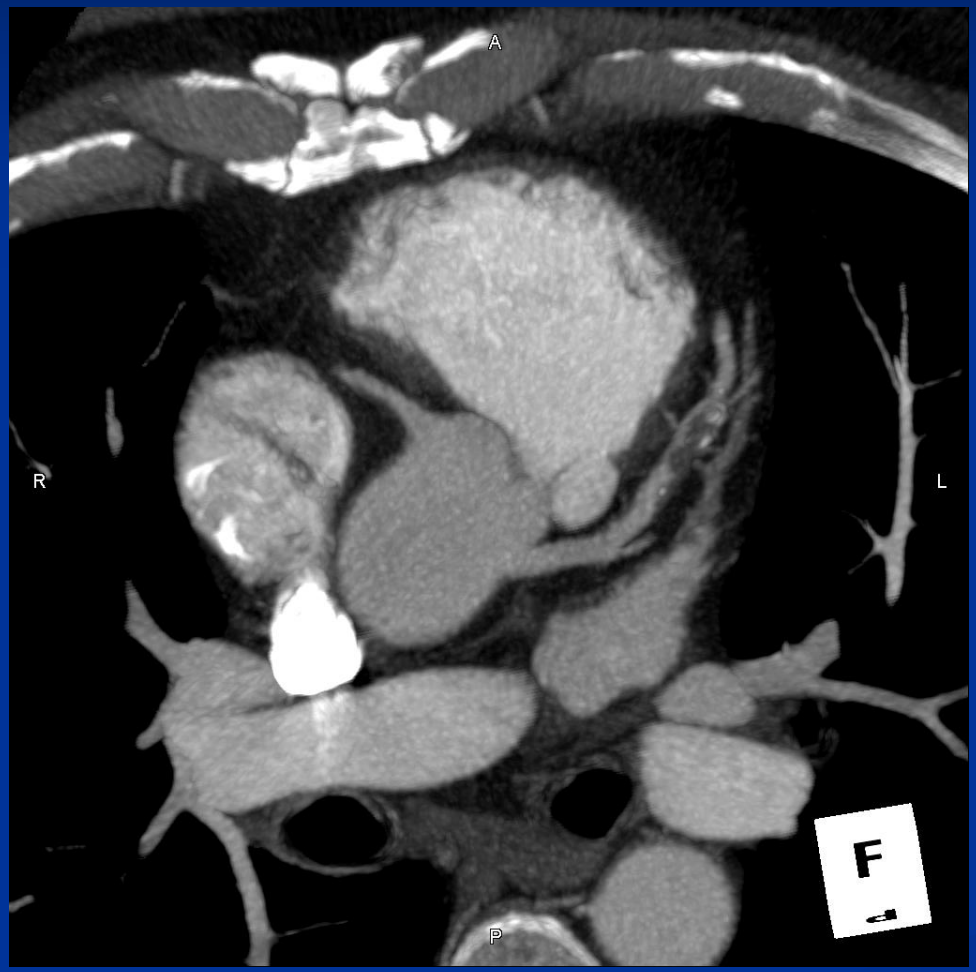
- Acute chest pain-ED patients
- Electrophysiology—Pulmonary/coronary veins
- Congenital heart disease—Cardiac MRI/echo primary imaging modalities

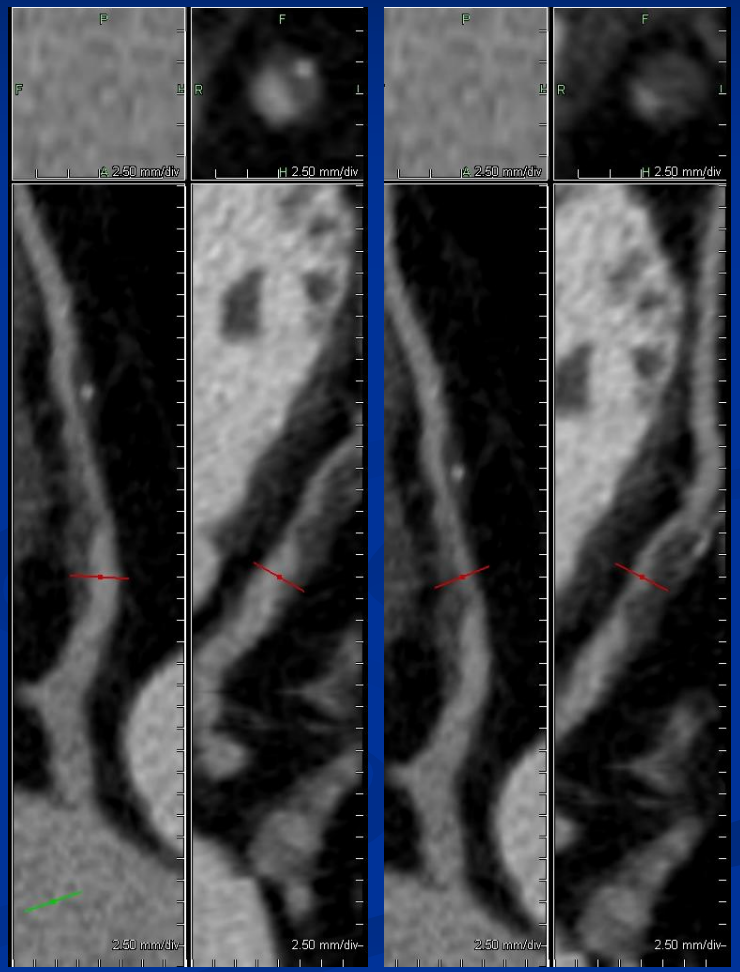
Vessel Wall Imaging With MDCT

Vulnerable Plaque

Vessel Wall Imaging With MDCT

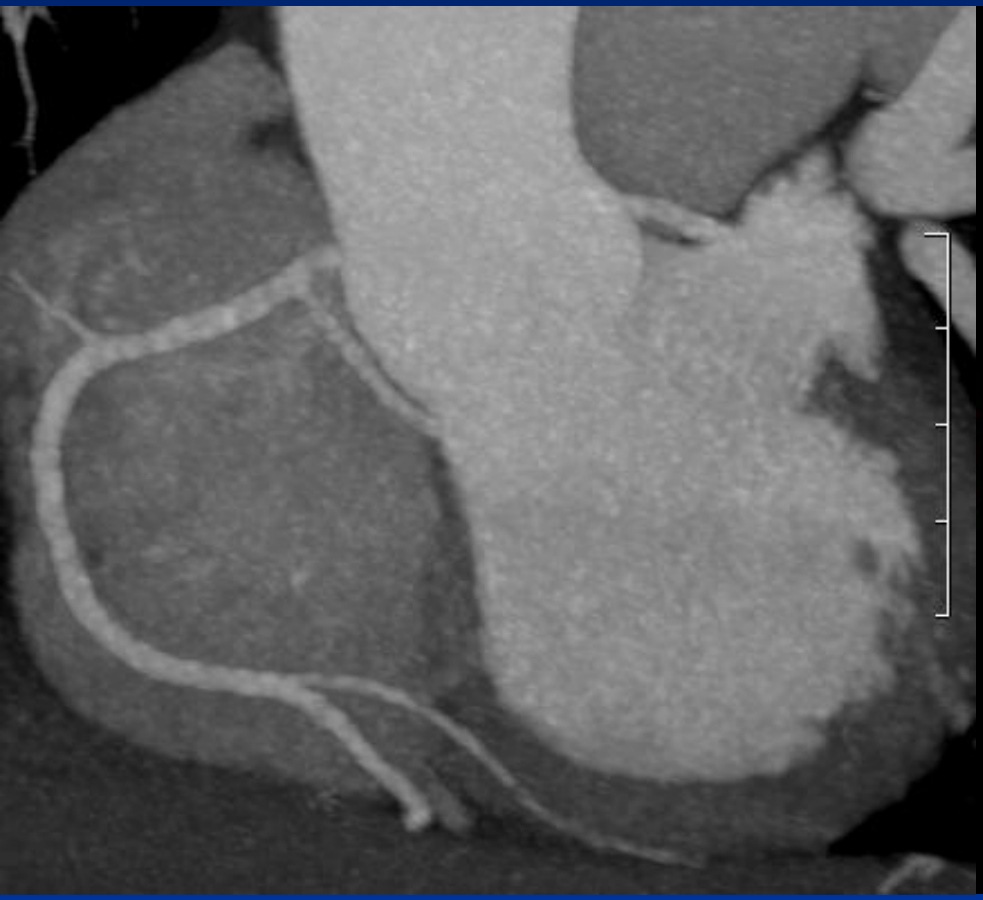
Vulnerable Plaque

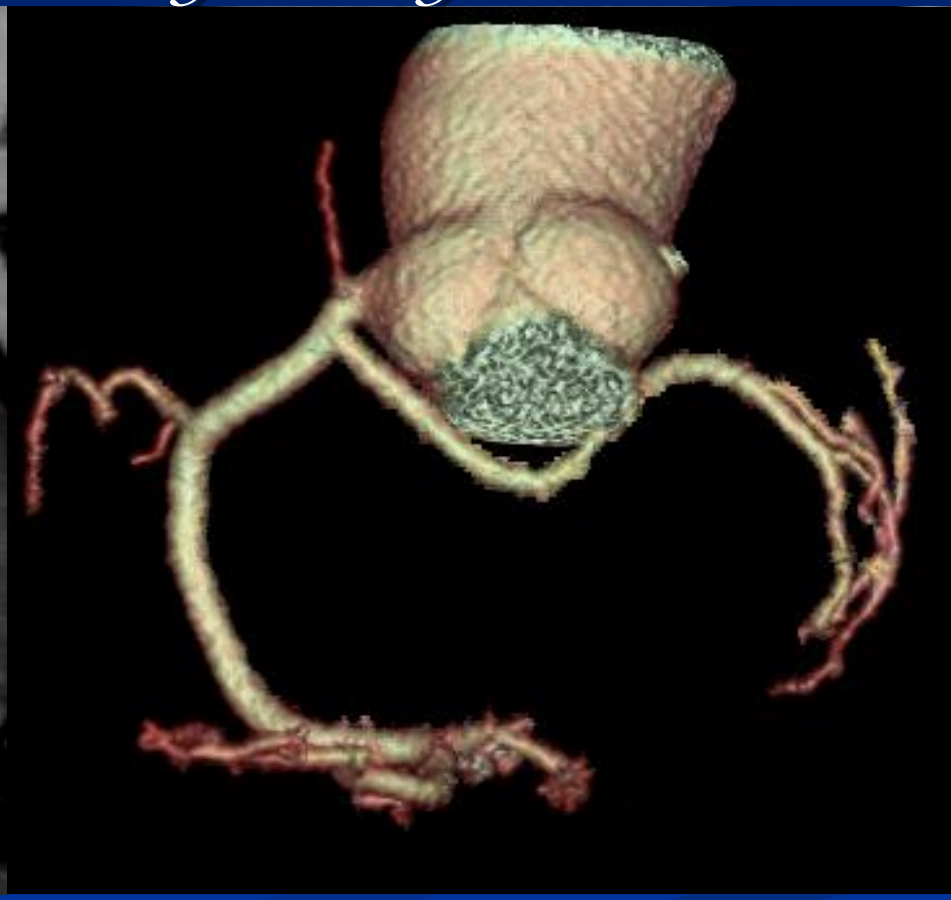




Complex Coronary Anatomy

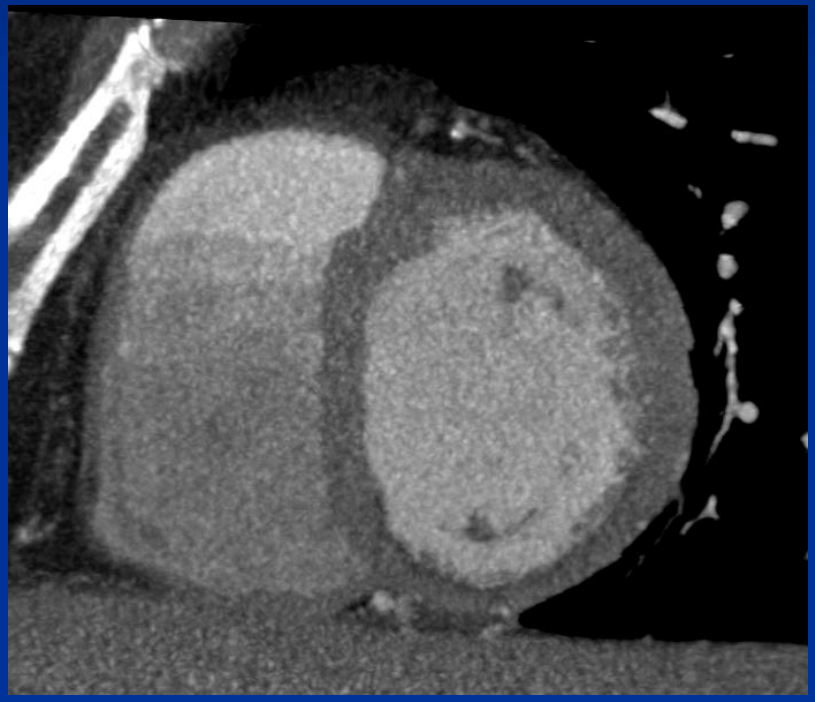
Anomalous Coronary Artery

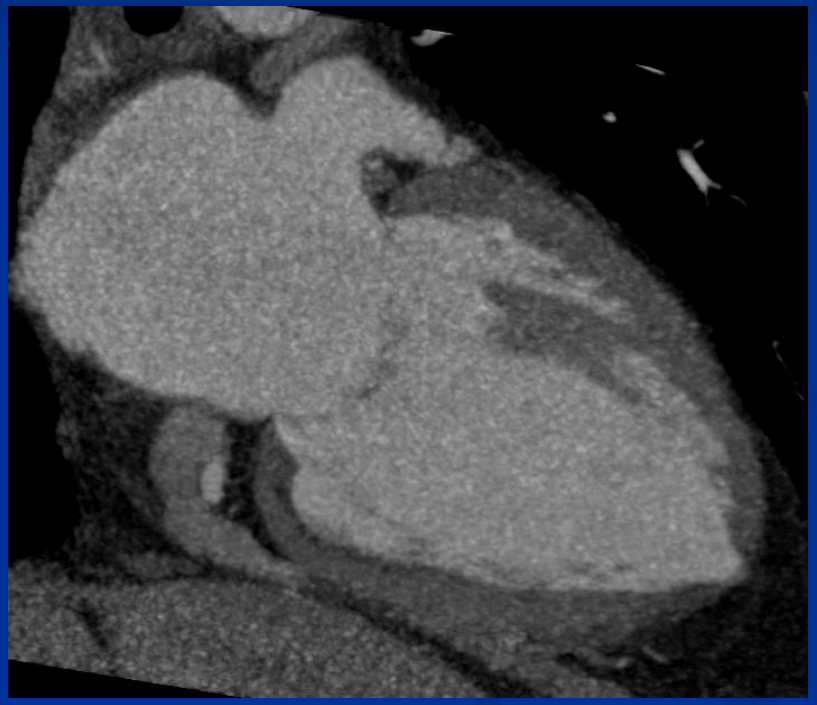




Cardiac MDCT

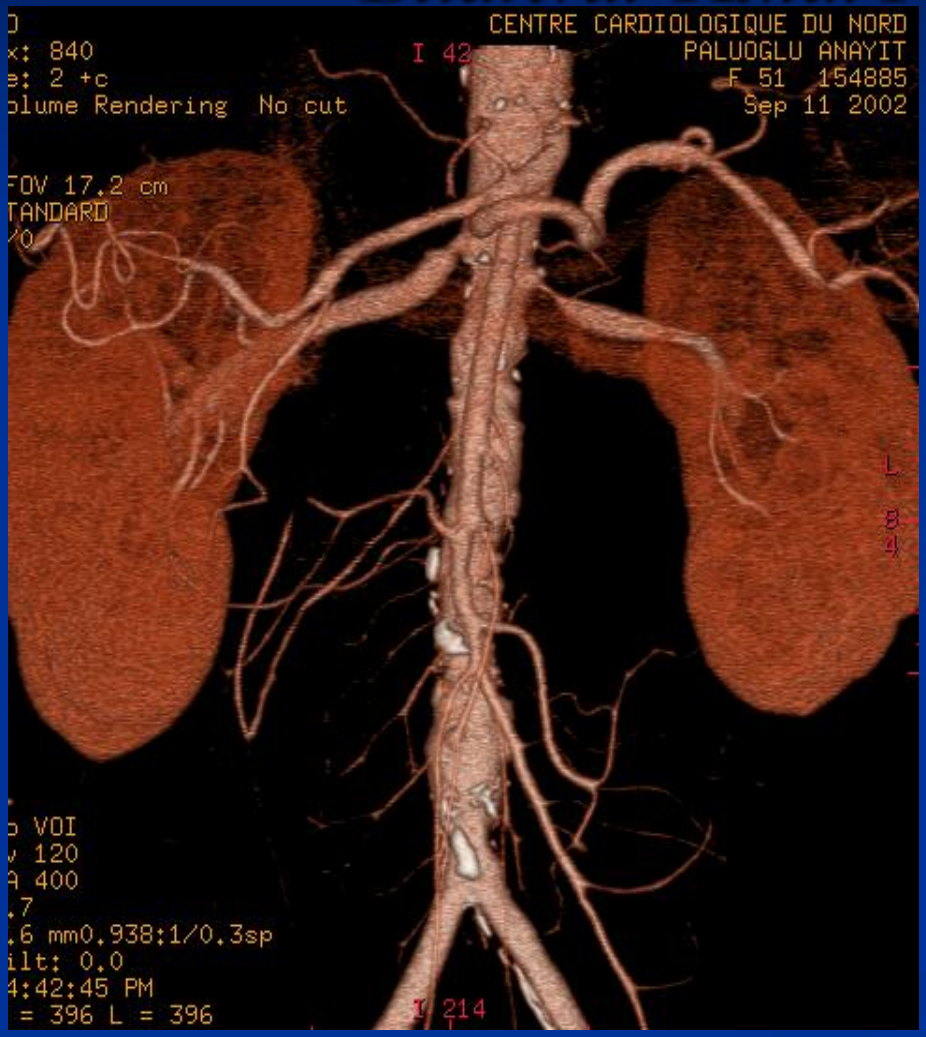
Non-Coronary Applications – Infarct Imaging





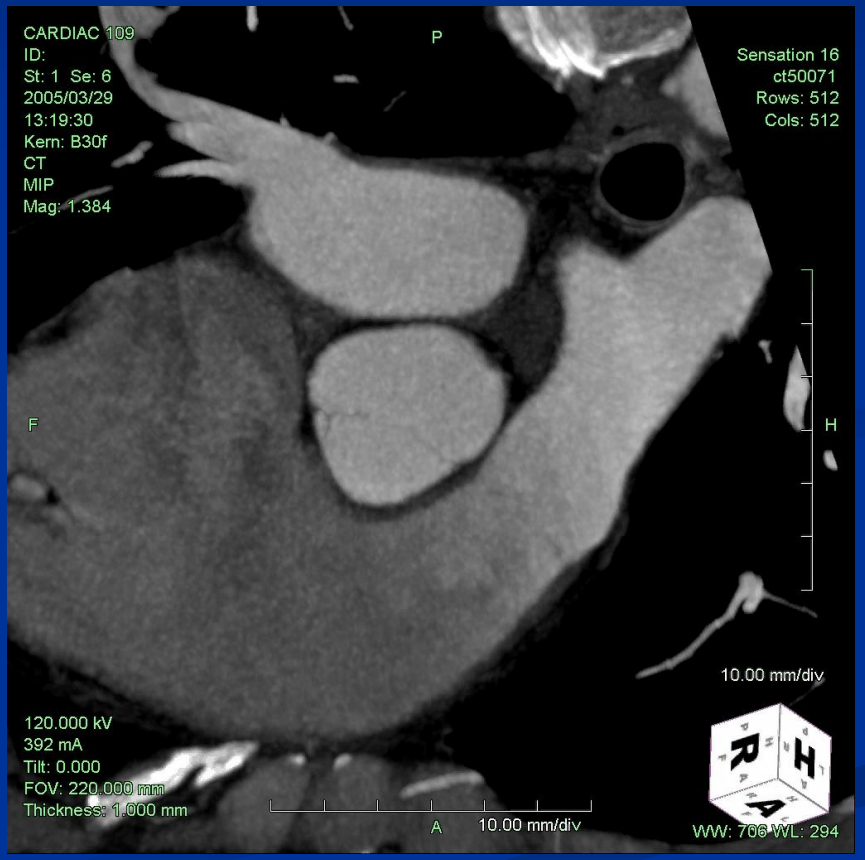
MDCT Imaging

Bilateral Renal Artery Stenosis



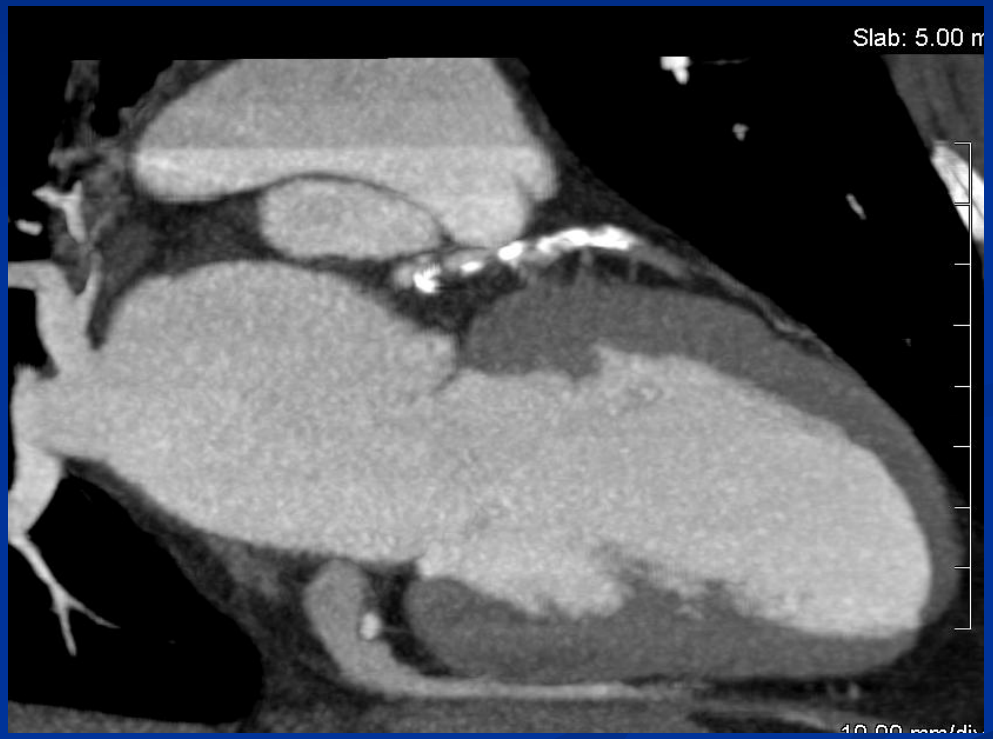
Vessel Wall Imaging With MDCT

Rocks of Calcium…



Vessel Wall Imaging With MDCT

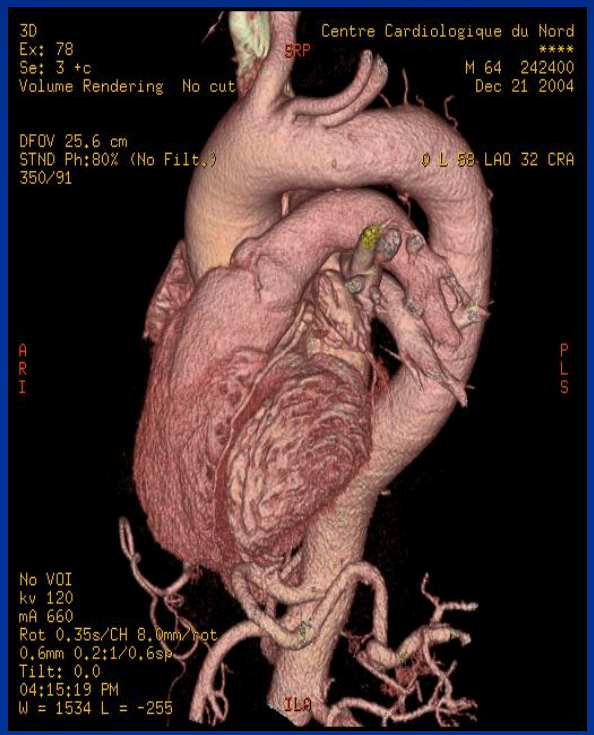
Rocks of Calcium…



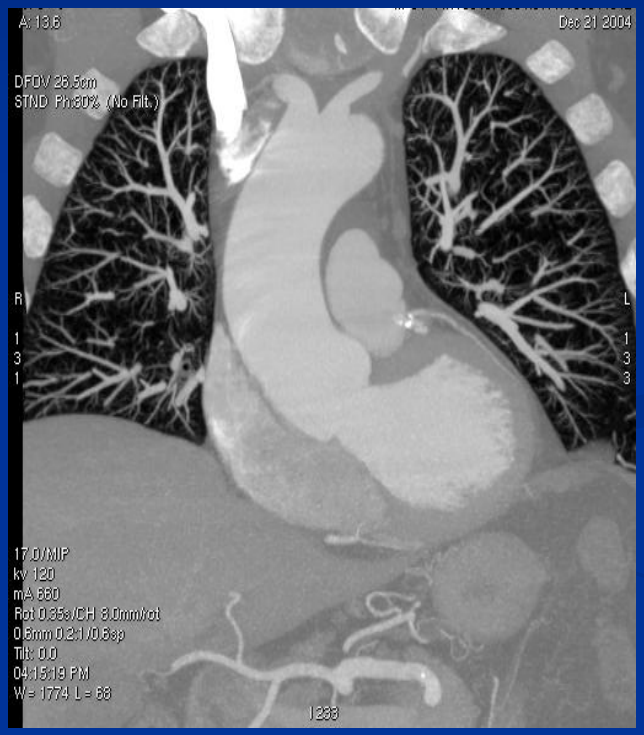
Vascular Imaging In ED

"Triple Rule-Out" In Single Setting

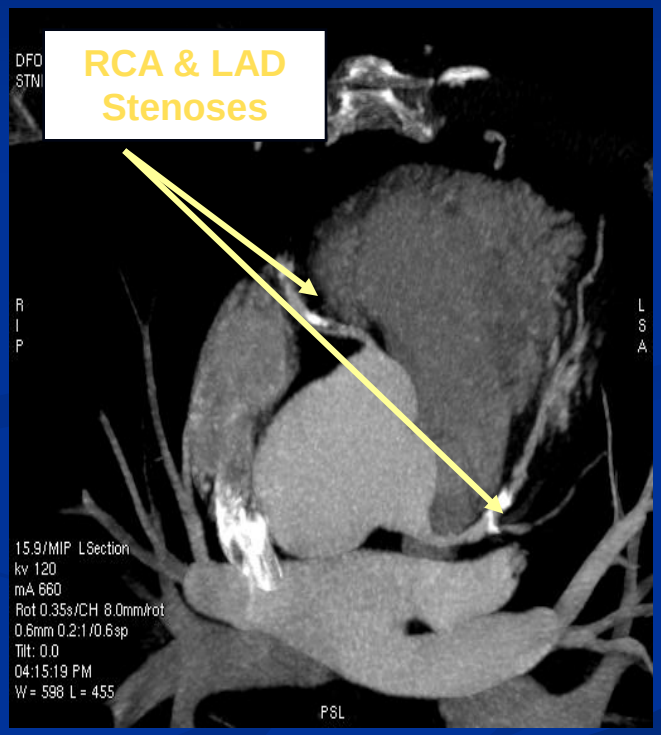
70 year old male with chest pain
Heart Rate 70bpm
292 mm coverage in 12.6 sec
SnapShot Burst at 0.35sec



Aortic Dissection



Pulmonary Embolism



Coronary Disease

Vascular Imaging In ED

"Triple Rule-Out" In Single Setting

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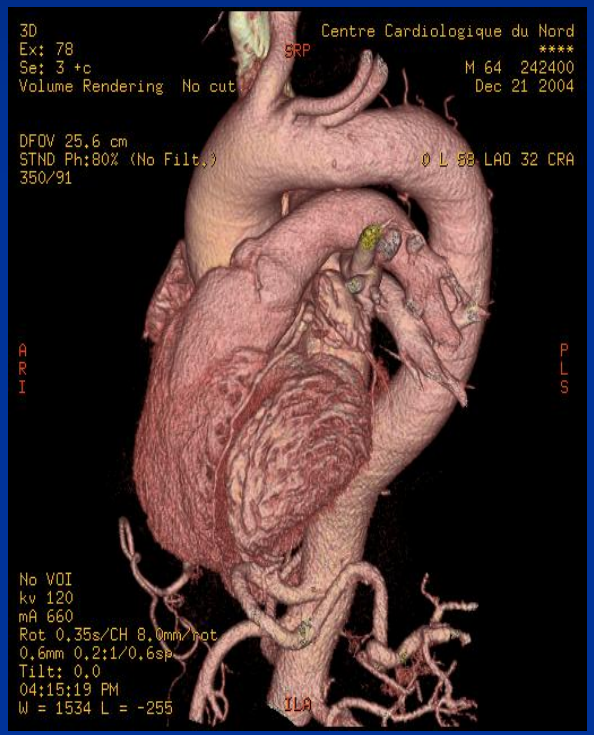
Heart Rate 70bpm
292 mm coverage in 12.6 sec
SnapShot Burst at 0.35sec



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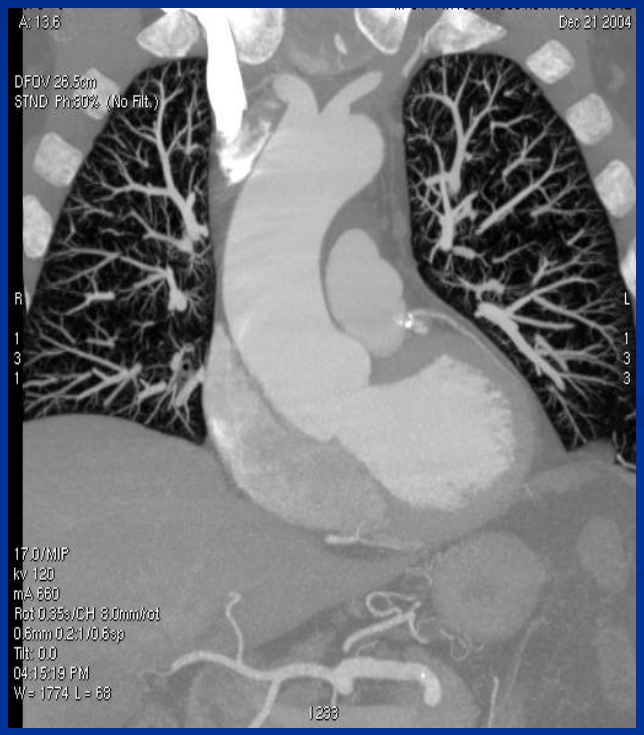
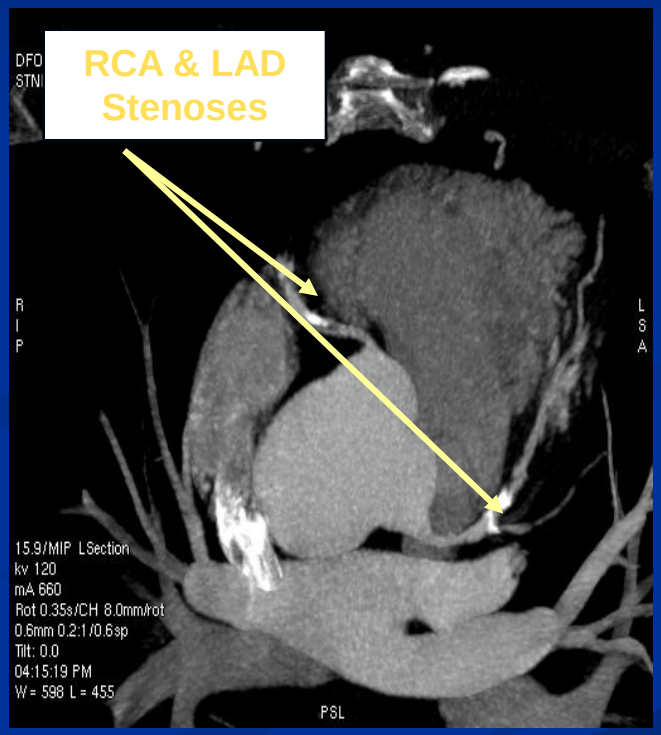


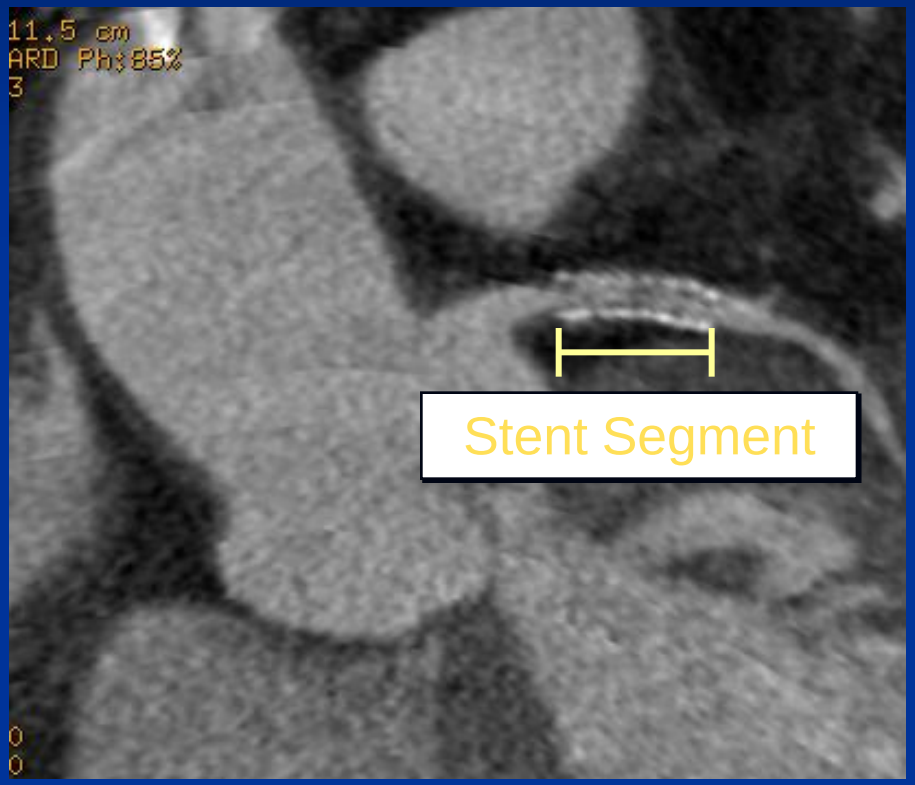
Pulmonary Embolism

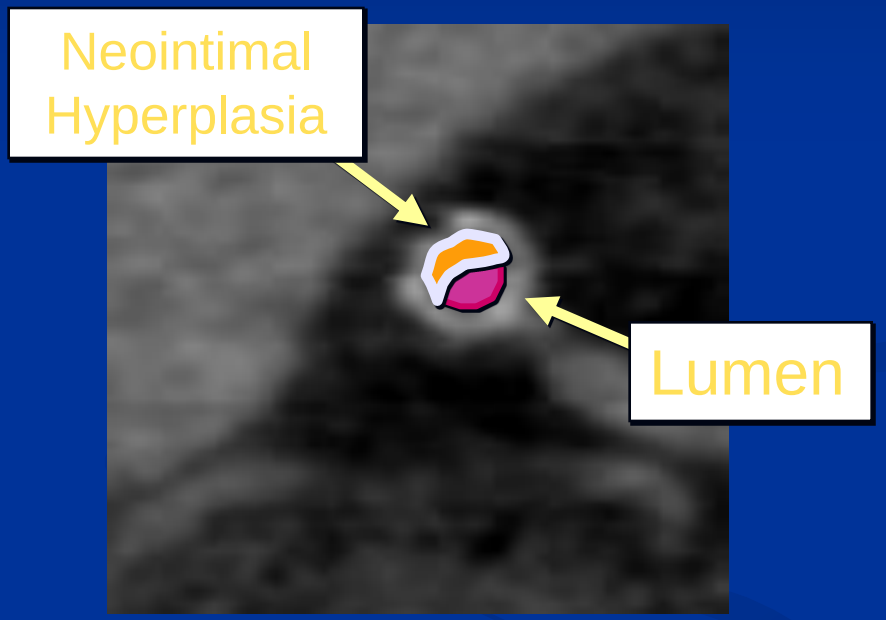


Coronary Disease

MDCT Assessment

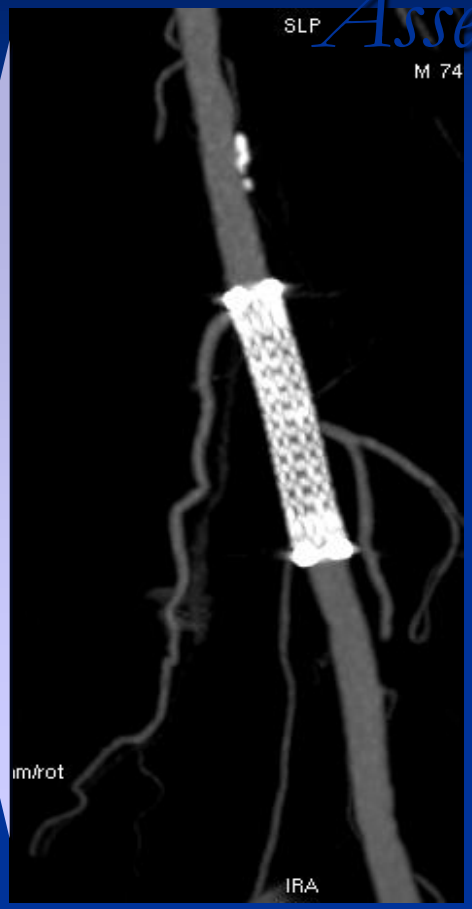
In-Stent Restenosis

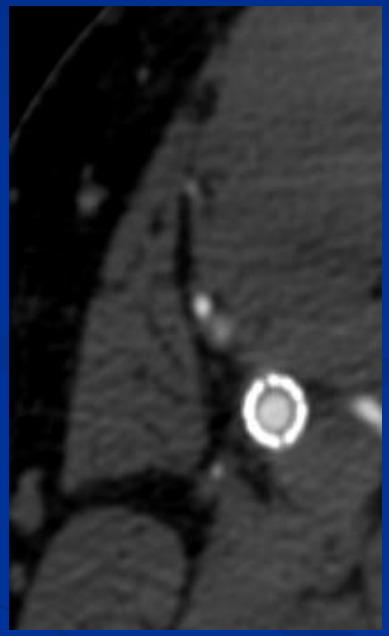




MDCT Imaging

Run-Off & Patency Assessment





MDCT

The Hurdles

- Technical
  - Equipment, software, workstations, heart rate control, CT techs, networking
- Clinical
  - Appropriateness, clinical indications, protocols
- Lack of standards
  - Physician training and competency, over-reads
- Patient safety
  - Radiation exposure

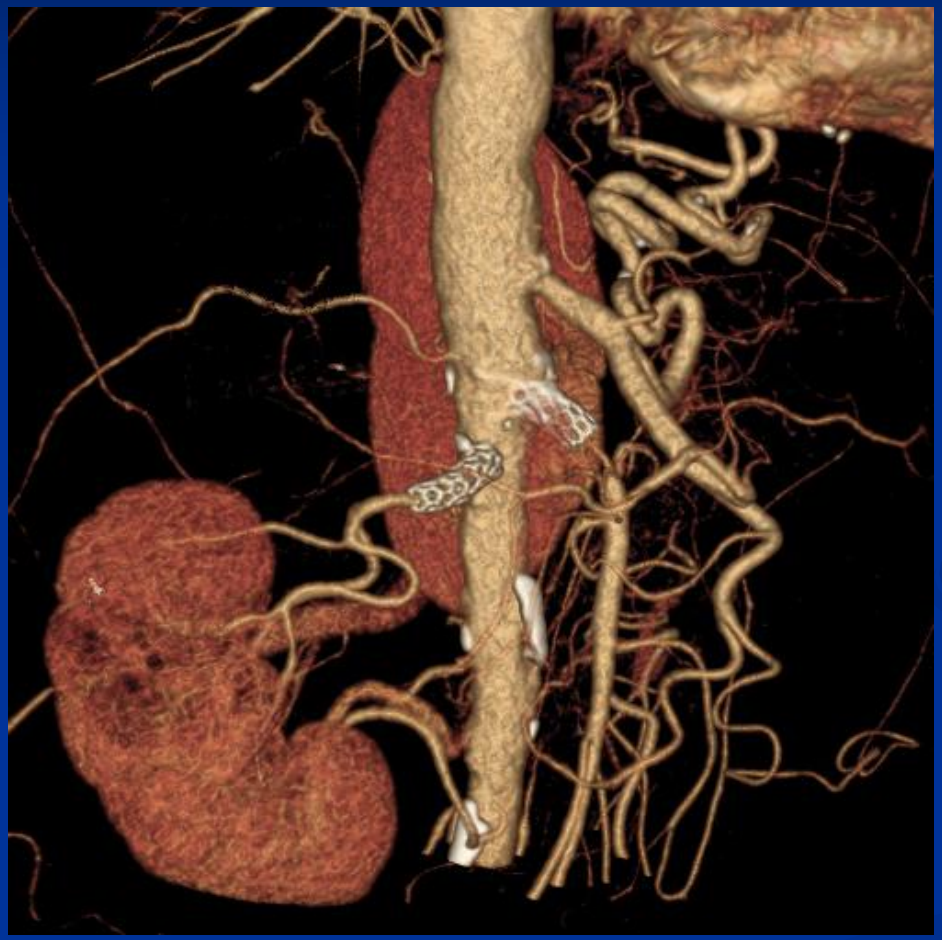
Summary

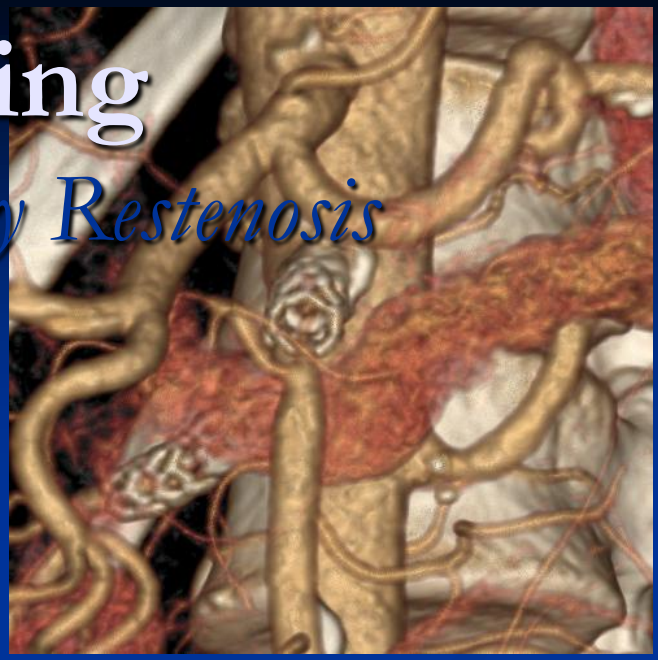
Cardiovascular CT

- Evolving experience in vascular imaging
- Remaining issues
  - Need for beta-blockade
  - Breathing – image misregistration
  - Artifacts – calcium
  - Obesity
  - Radiation
- Excellent resolution for noninvasive vascular exam
- Expanding and developing, but HERE AND

MDCT Imaging

Mesenteric & Renal Artery Restenosis





64-Slice Coronary Angiography

More Than Meets The (Angiographic) Eye…

Entire coronary tree evaluable?	55/59 pts
Sensitivity for >50% stenosis	73%*
Sensitivity for plaque detection	84%†
Specificity for plaque detection	91%†

*17/18 pts, 24/27 stenoses treated with revasc correctly identified

†Comparison with IVUS

Vessel Wall Imaging With MDCT

Accuracy With IVUS

	N=37 (58 segments)
Hypoechoic (soft)	78%
Hyperechoic (fibrous)	78%
Calcium	92%

Leber et al. *JACC* 2004

MDCT Coronary Angiography
ST. Vincents Heart Center

- Scheduling: **583-5151**
- Questions/issues: Contact Michael Elliott
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