

Emerging Techniques
in
Non-Invasive Cardiac Imaging:
Cardiac CT

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Spokane Society of Internal Medicine

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Non-Invasive Cardiac Imaging:
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Faculty Disclosure
Michael Williams, MD
Dr. Williams has indicated that he does not have
any relevant financial relationships or
affiliations that may have a direct bearing on
the subject matter of this CME activity.

Multi-Detector CT

- What is MDCT?
- Current uses
- Limitations
- How does it fit in with other tests?
- What happened to cardiac MR?

Multidetector CT

- Not a Coronary calcium score
- MDCT provides a non-invasive coronary angiogram

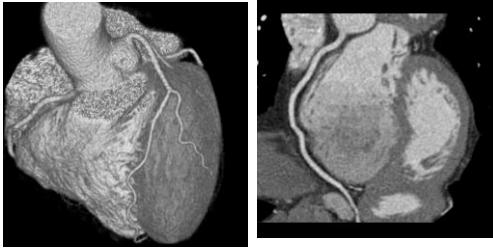
Multidetector CT Coronary Angiography

- Current CT scanners with 64 detectors can image coronary arteries
 - Became available in 2005
- Imaging resolution
 - Spatial: 0.4mm (invasive coronary angiography = 0.2mm resolution)
 - Temporal: 165msec (invasive coronary angiography = 8msec resolution)

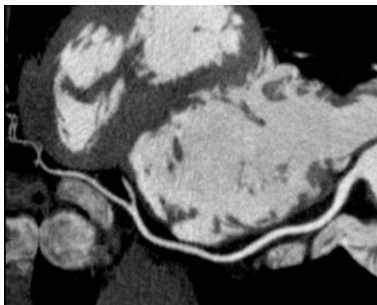
Multidetector CT Coronary Angiography

- Contrast enhanced
- Requires slow heart rate
 - ≤ 60 bpm

MDCT Coronary Angiogram



Curved Multiplanar Imaging



CT – Cardiac Applications

- *Coronary Calcification (CAS)*
- ***Non-invasive Coronary Angiography***
- *Aortic Assessment (aneurysm, dissection)*
- *Pulmonary Embolism*
- *Pericardial disease*
- *Congenital heart disease*
- *Cardiac thrombi & tumor*
- *Quantification cardiac anatomy & volumes, global & regional function*
- *Venous Anatomy – Pulmonary and Coronary veins pre-procedure*

MDCT Coronary Angiogram

- Allows visualization of coronary art. Anatomy
 - Can indentify/exclude plaque
 - Can estimate stenosis
 - 0-24%
 - 25-49%
 - 50-74%
 - 75-99%
 - Complete occlusion

Non-invasive Angiography

Con's

- Poor visualization of small vessels (< 1.5mm)
- Artifacts caused from extensive calcification, stents or extensive clips after CABG (esp. IMA-grafts)
- Use of contrast media
- Radiation exposure

Non-invasive Angiography (CTA)

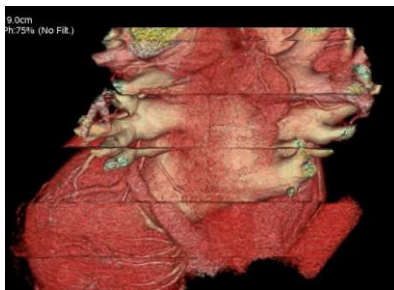
*Clinical Contraindications**

- Renal insufficiency (creatinine > 2.0 mg/dl)
- Severe dye allergy
- Extensive calcification
- Arrhythmias
- Rapid resting heart rate

**BEWARE HIGH CALCIUM
SCORES**



Registration Errors



Patient preparation

- Review ECG prior
- Give beta blocker - obtain HR < 60
 - 100mg metoprolol the night before
 - IV beta blocker immediately before
 - Nitro spray immediately prior to imaging
- Obtain calcium score
 - Proceed if score < 400-600

Calcium Score

- If calcium score is high (400-600), abort scan

What Studies Validate MDCT?

Accuracy Study

- Diagnostic performance of 64-multidetector row coronary computed tomographic angiography for evaluation of coronary artery stenosis in individuals without known coronary artery disease

• Matthew Budoff et al. JACC 2008 vol 52 no 21 p. 1724-1732

Accuracy Study

- Low and intermediate risk patients without hx CAD
- Chest pain evaluation with MPI
- Referred for invasive coronary angio (ICA)
- Multicenter prospective, blinded readers
- Mostly private practice environment
- Unreadable segments were not excluded
- High calcium scores were not excluded
- All BMI's were included

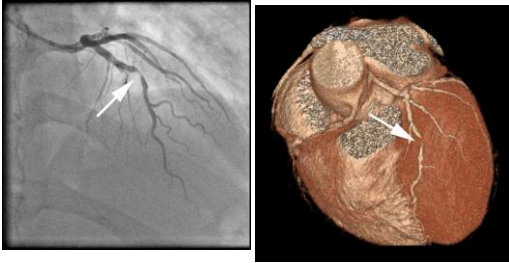
Accuracy Study

- 230 patients
- Assessed per patient and per vessel segment
 - Per pt to detect >70% stenosis;
 - Sensitivity – 94%
 - Specificity – 83%
 - PPV – 48%
 - NPV – 99%
 - Per vessel segment to detect > 70% stenosis
 - Sensitivity – 84%
 - Specificity – 92%
 - PPV – 36%
 - NPV – 99%
- No exclusions regardless of vessel size, calcification, heart rate and obesity

Accuracy Study

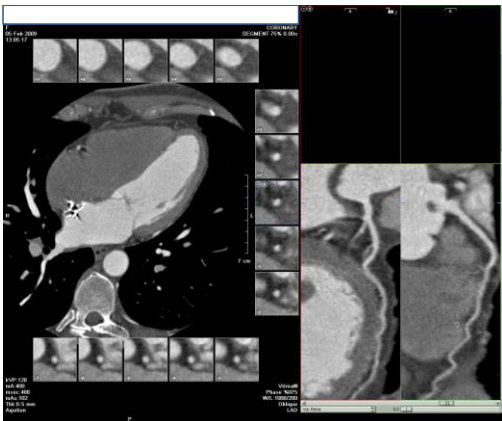
- Specificity of 83% equals that of myocardial perfusion imaging
- 99% NPV is better than any other test
 - This is for >70%
 - Also provides plaque information
 - No plaque vs any plaque

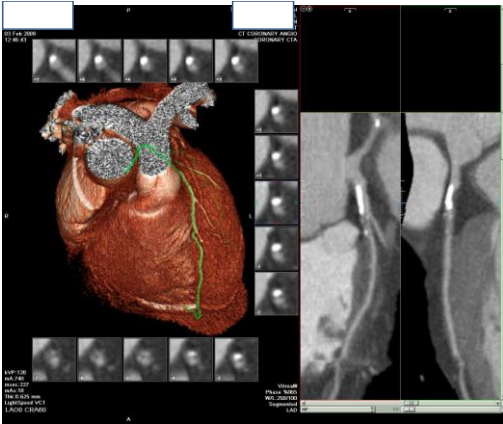
High Specificity for Obstruction



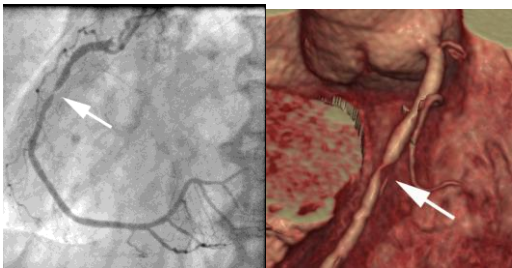
Accuracy Study

- The rest of the story
 - What about ruling in obstructive CAD? PPV 50%
 - Spatial resolution 0.1mm ICA, 0.4mm CCTA
- The true power of CCTA is in its ability to define plaque
 - Long term prognostic value related to the extent and severity of plaque, beyond the presence or absence of obstructive CAD

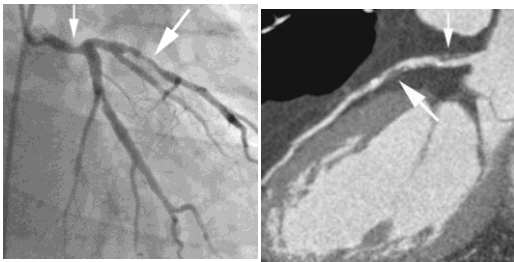




Exquisite Detail of Anatomy



Lumen + Plaque Burden



Accuracy Study

- MDCT has a role in the evaluation of chest pain in low and intermediate risk patients
 - Higher NPV than myocardial perfusion imaging
 - Prevent many negative angiograms
 - Less expensive than both MPI and ICA

Limitations of Coronary Angiography

- 15-35% of all angiograms done have no significant luminal narrowing
- Luminogram – no wall (plaque) information
- Average costs high
 - 2003 – 707,000 caths – charges \$14.5 B (\$20,500 per case)

Additional Strengths of MDCT

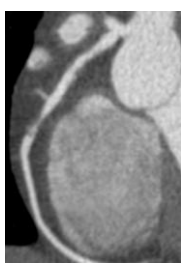
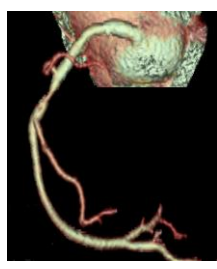
Additional Strengths of MDCT

- Outpatient w/u of chest pain

Additional Strengths of MDCT

- ER and inpatient work-up of chest pain

Immediate triage, Dx, and interventional plan



Chest Pain Evaluation in the ER

- Two studies
 - “Coronary CTA in Early Triage of Patient with Acute Chest Pain” Udo Hoffmann et al, ROMICAT Trial
 - JACC vol 23 No 18 2009
 - “A Randomized Controlled Trial of Multi-Slice Coronary CT for Evaluation of Acute Chest Pain” James Goldstein et al (Royal Oaks Michigan)
 - JACC vol 49 No 8 2007

ROMICAT Trial

- Triage of CP in ER in low and intermediate risk population
- Observational cohort
- 64 slice CT obtained before admission
- Endpoints of ACS during admission and 6 month f/u
- 368 patients
- 31 (8%) had ACS

ROMICAT Trial

- 368 patients
 - 50% had no CAD
 - 31% had nonobstructive CAD
 - 19% had obstructive CAD or inconclusive findings

ROMICAT Trial

- Sensitivity and NPV
 - For no CAD
 - 100%
 - For CAD with significant stenosis
 - 77% and 98%
 - Specificity 54% (overcalled % stenosis)
 - Extent of plaque and % stenosis predicted ACS
 - Independent of TIMI risk score; p=0.0001

Goldstein Study

- ER evaluation of chest pain
- Randomized to CT (99) vs SOC (98)
- Minimal CAD on CT – discharged
- >70% - Invasive cath
- Intermediate/non-diagnostic CT – nuclear study

Findings

- 75% had no CAD or obstructive CAD
 - 67 normal, 8 obstructive
- 25% had intermediate/non-diagnostic scan
 - required nuclear study

Findings

- CT reduced time to d/c
 - 3.4 hours vs 15.0 hours
- CT reduced cost
 - \$1586 vs \$ 1872
- CT arm required fewer repeat evaluations
 - 2 vs 7

Comparison of CTA and MPI

- Traditional workup with MPI
 - 15 hour average stay
 - Cost of MPI = \$2800
- CTA
 - 3 hour average stay
 - Cost of CTA = \$900-\$1400

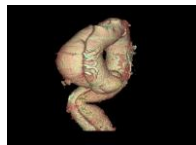
ER Evaluation of Chest Pain

- Potential for more rapid and cost effective evaluation with fewer repeat evaluations
- MDCT does not provide a "triple rule-out"
 - PE, CAD, dissection

Additional Strengths

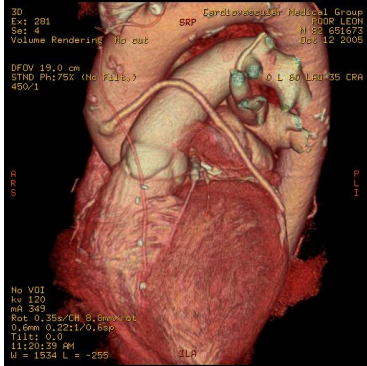
- Aorta disease
- Coronary grafts
- Anomalous coronary arteries

Aortic Dissection

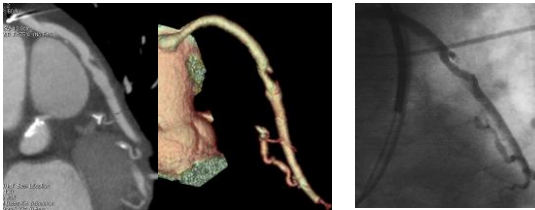


Bypass Grafts

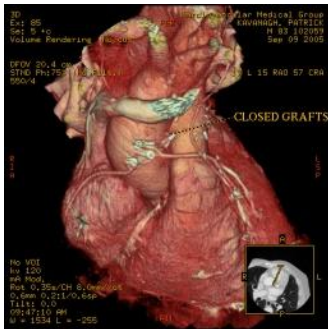
Open Bypass Grafts



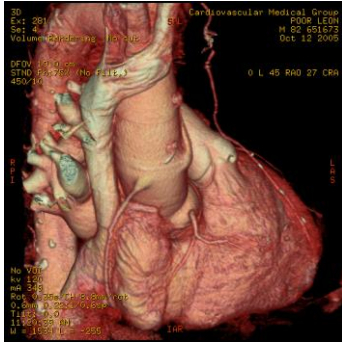
Bypass Grafts

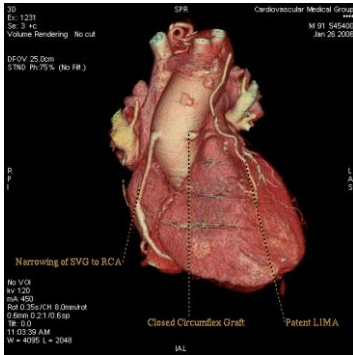


Closed Bypass Grafts



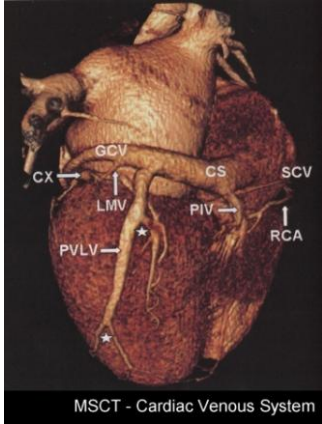
Bypass Grafts





Coronary Venous Anatomy

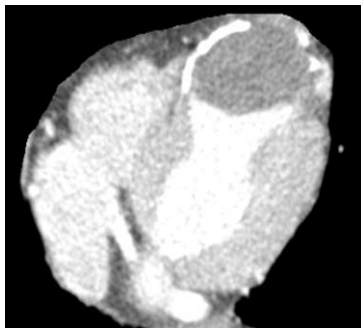
- Map veins prior to implantation of a coronary sinus pacer lead



Apical Thrombus and Infarction

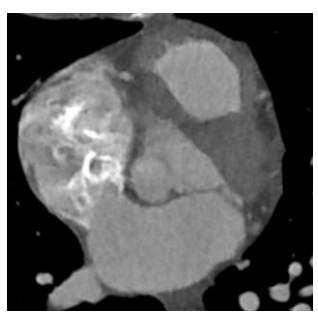


Apical Thrombus

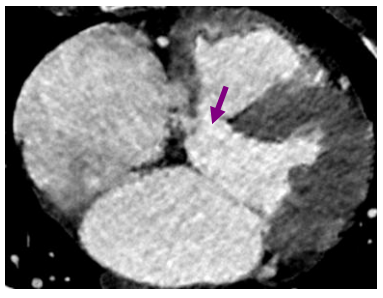


Congenital Heart Disease

ASD



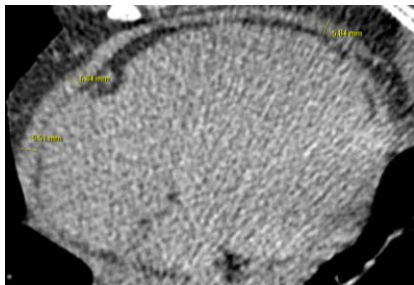
VSD



Patent Ductus Arteriosus



Pericardial Thickening



Constrictive Pericarditis



How Concerned Should We Be With Radiation Exposure?

Radiation theories

- Health effects from radiation only observed at doses > 100mSv given rapidly
 - Less than that is theoretical
- One study* looked at 6500 radiology techs who received 50 –150 mSv/yr over 29 years. There was no increase in malignancies

*Radiology Techs. Jablon et al. Radiology 126:677-679, 1978

PATIENT SAFETY

Medical Radiation Doses

• Chest (PA & Lat)	0.6 mSv
• Lung V/Q Scan	1.5
• Natural background(annual)	3.0
• Coronary Angiogram	4.6-15.8
• PTCA	7.5-57
• CT Chest	8.0
• Tc sestambi	8.9
• Tc pertechnetate	14.4
• Tl chloride	17.0

Health Physics Society 2005

Radiation Dose

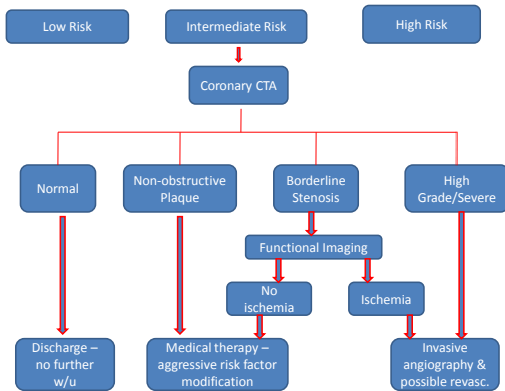
- Average MDCT 12 mSv = 600 chest X-rays
 - 1.2 X dose from abd. CT
 - Can be reduced to 3-5 mSv with dose modulation
 - No EF
 - New “Flash” scanners – 0.7 mSv
- Thallium – 18 mSv
- Sestamibi (myoview) – 7.5 mSv (for 45mCu)
- Coronary angiogram – 3.4 mSv

How Should CT Be Integrated?

- Workup of chest pain
- Screening of asymptomatic patients

Evaluation for CAD Currently Available Techniques

- ECG
- Stress (treadmill or pharmacologic) ECG
- Stress ECG with imaging
 - Echo
 - Nuclear



Assessment and Screening for CAD

- Asymptomatic patients, without known CAD
 - Low risk
 - Intermediate risk
 - High risk

Assessment and Screening for CAD

- Available tests
- Current recommendations of ACC/AHA

APPROPRIATENESS CRITERIA

APPROPRIATENESS CRITERIA

Joint Societies Document 2006

- ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR
- Based on scientific evidence and practice experience of panel
- "Potential uses and advantages over existing technology"
- "Initial guides for the responsible use of CCT"
- 39 indications for Cardiac CT
 - *13 appropriate(score 7-9)
- - *12 uncertain(score 4-6)
 - *14 inappropriate(score 1-3)
- 27/39 indications for CAD detection JACC 2006:1475-97

APPROPRIATENESS CRITERIA

Pre Test Probability of CAD

Use the same criterion used to determine other testing modalities:

- Clinically the WRONG test:
 - *High pre-test probability
 - *Low pre-test probability
- Clinically the RIGHT test:
 - *Intermediate pre-test probability

APPROPRIATENESS CRITERIA

Appropriate Indications

- Evaluation of chest pain
 - *Chest pain syndrome
 - *Intermediate pre-test probability CAD
(ECG uninterpretable OR unable to exercise)
 - *Acute chest pain
 - *Intermediate pre-test probability(nI ECG/enz)
 - *Equivocal stress test(exercise,perfusion,str echo)
 - *Suspected coronary anomalies JACC 2006:1475-97

APPROPRIATENESS CRITERIA

Appropriate: structure and function

- Morphology:
 - *Complex congenital heart disease
 - *New onset CHF to assess coronary arteries
- Evaluation of intra/extra cardiac structures:
 - *Cardiac mass
 - *Pericardial conditions
 - *Pulmonary vein anatomy pre ablation
 - *Coronary vein anatomy pre CRT/BIV pacer
- Evaluation of aortic and pulmonary disease
 - *Aortic dissection/aneurysm
 - *Pulmonary embolism

APPROPRIATENESS CRITERIA

Inappropriate Indications(consensus)

- Evaluation of chest pain:
 - *High pre-test probability CAD
 - *ECG/enzyme abnormalities
 - *Abnormal stress test(exc.,perf.,str. echo)
- Asymptomatic-CAD detection
 - *Low CHD Framingham risk

JACC 2006:1475-97

APPROPRIATENESS CRITERIA

Uncertain Indications

- Detection of CAD-Asymptomatic:
 - *High Framingham CHD risk
 - *Mod/High Fram. Risk with abn. CA score
- Pre Op eval. Noncard. Surg.-interm/high risk:
 - *intermediate pre-test probability CAD
- Evaluation chest pain post PCI/CABG:
- Evaluation ventricular/valve function:
 - *LV function in CHF or post MI(tech limited echo)
 - *Anatomy of native/prosthetic cardiac valves(tech limited echo)

JACC 2006:1475-97

APPROPRIATENESS CRITERIA

Uncertain Indications

("score variability, markedly differing opinions")

- Evaluation of chest pain:
 - Intermediate pre-test probability CAD
(ECG interpretable AND able to exercise)
- Acute chest pain:
 - Low pre-test probability CAD
(no ECG changes/enzymes negative)
 - High pre-test probability CAD
(no ECG changes/enzymes negative)
- "Triple rule out"—exclude CAD,PE,Aortic dissection
(intermediate pre-test probability for one of the above)

APPROPRIATENESS CRITERIA

Contraindications

- True:
 - *Irregular heart rate(AF) unless very regular
R-R intervals
 - *Inability to follow commands or hold breath
- Relative:
 - *Very high Ca scores-greater than 1000
 - *Severe contrast allergies
 - *High heart rate not amenable to medication
 - *Renal dysfunction
 - *Morbid obesity

Case 1- MH

- 45 year old female
- Brother had CABG
- No other risk factors for CAD; no DM, HTN, DL (LDL 115, HDL 50), tobacco use, obesity
- Physically active
- No ischemic symptoms
- Normal resting ECG

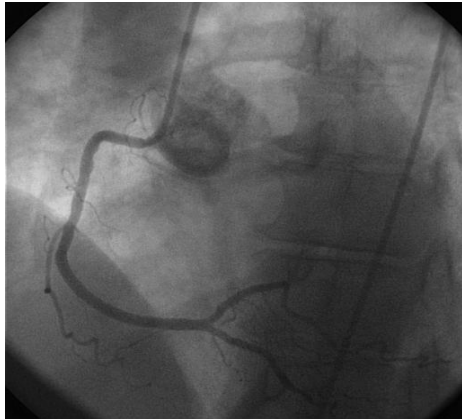
Case 1- MH

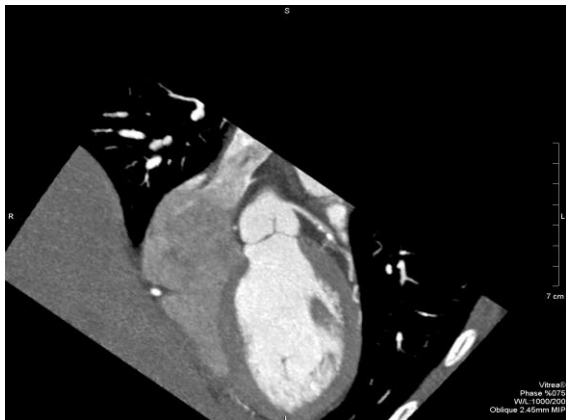
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- Physically active
- No ischemic symptoms
- Normal resting ECG

Case 1- MH

- Next step?
 - No further w/u
 - ETT nuclear study
 - Invasive coronary angiogram
 - CT coronary angiogram



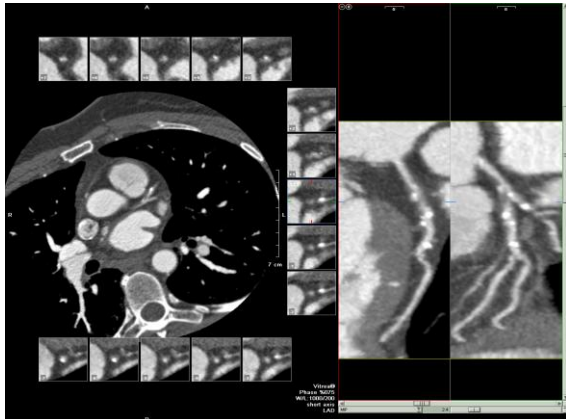


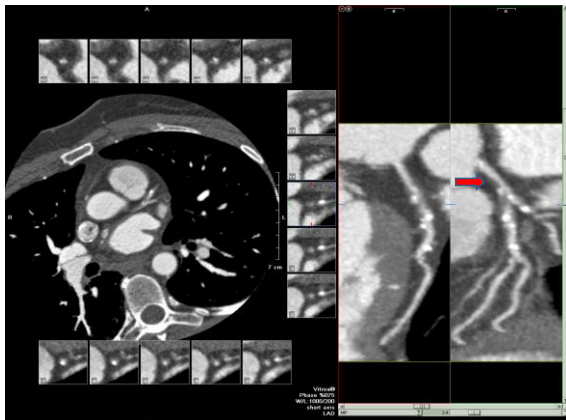


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Michael P. Williams, M.D.

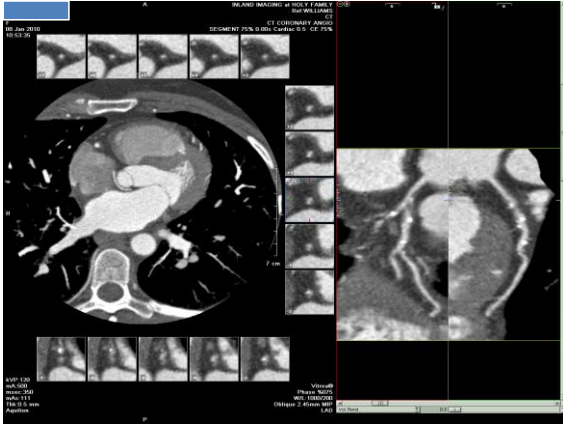


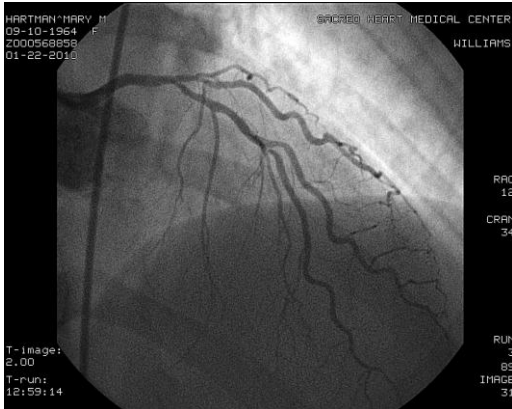


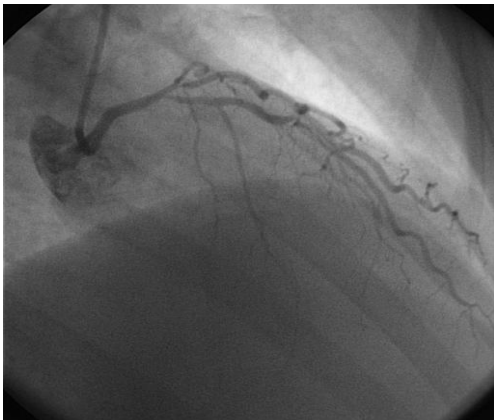


Emerging Techniques in Non-Invasive Cardiac Imaging: Cardiac CT

Michael P. Williams, M.D.







Case 1 MH

- IVUS – 80% Left Main, ostium of D1
- FFR – 0.60 without adenosine
 - =resting ischemia
- Outcome -- CABG

Case 2 TD

- 34 year old female
- Diagnosed with dyslipidemia at age 16
 - Most recent labs
 - TC - 314
 - LDL - 230
 - HDL - 76
 - TG - 41
- Strong family history of premature CAD

Case 2 TD

- Myalgias on two statins
 - Took months to recover
- Did not tolerate Niacin
- Multiple OTC treatments without significant effect on total cholesterol

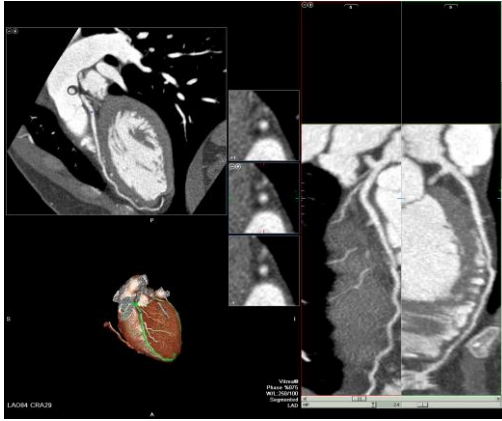
Case 2 TD

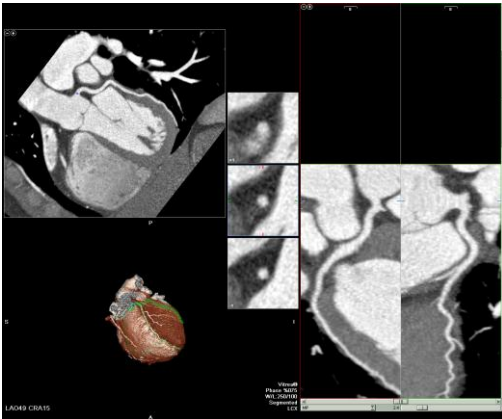
- Question from patient – how important is it to try another statin?

Case 2 TD

- Options
 - hsCRP
 - Carotid IMT
 - Calcium score
 - Cardiac CT for plaque









Case 2 TD

- No guidelines, long term f/u
