

Coronary / Cardiac CT in Private Practice

Richard Hallett, MD

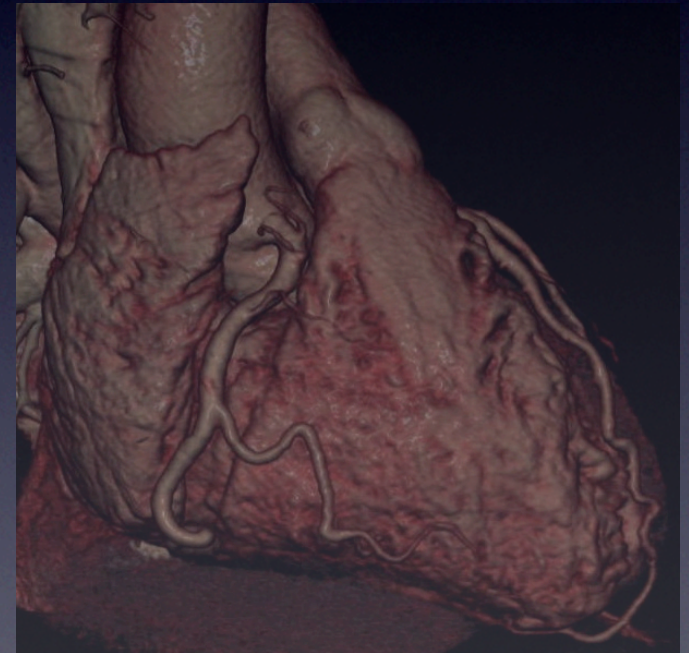
Northwest Radiology Network

Indianapolis, IN

Clinical Assistant Professor,

Stanford University

Stanford, CA



Disclosures: None

Handouts, more: <http://stanford.edu/~hallett>



Overview

- **Technique for CCTA**
- **Indications / Appropriateness**
- **Logistics of cardiac CT in the “Real World”**
- **Case Studies**



Handouts and more: <http://stanford.edu/~hallett>

Northwest Radiology: Background



- 50 radiologist private practice group based in Indianapolis
 - “Subspecialized”
- 17 hospitals (50-650 beds), 10+ Imaging Centers
 - St. Vincent Heart Center of Indiana
- Member of Strategic Radiology
- RSNA Bronze VIP Sponsor

NWR

- 24/7 in-house Nighthawk
- Separate Management Services Organization (MSO) – owned by Rads
 - Telerad services for own contracts and others
 - In-house billing for own and other practices

NWR IT Environment

- St. Vincent Network: McKesson RIS/PACS
- Practice PACS: legacy Stentor PACS w/ Centricity RIS and GUI
- Integrated Voice Transcription (Powerscribe) w/ editor backup
- ED TAT: ≤ 20 min. after study OK'd in PACS

CCTA Technique

Patient Screening
Patient Preparation
Scan
Reconstruction
Interpretation



Pre-CCTA Patient Screening

Medication	β Blockers (β 1 selective Blocker) i.e. Atenolol, Metoprolol	CA Channel Blocker i.e. Verapamil, Diltiazem	Nitroglycerin
Heart			
Sick sinus syndrome	++	++	0
Severe bradycardia	++	++	0
2nd / 3rd degree heart block	++	++	0
Hypotension (systolic BP < 100 mm Hg)	++	++	++
Severe aortic stenosis	+	+	+
Early myocardial infarction	+	+	++
Obstructive cardiomyopathy	0	+	++
Constrictive pericarditis	+	+	+
High doses of other agents depressing SA and AV nodes (digoxin, anti-arrhythmica)	++	++	0
Lung			
Asthma	++	0	0
Bronchospams	++	0	0
Severe COPD	++	0	0
Other			
Severe anemia	0	0	++
Increased intracranial pressure	0	0	++
Migraine sensitive to nitrates			++
Peripheral arterial occlusive disease	+	0	0
Hypersensitivity	++	++	++
Erectile dysfunction treated with nitrate based medications i.e. Viagra®, Sialis®, Levitra®			++
Pulmonary arterial hypertension treated with nitrate based medications, i.e. Viagra®			++
Glaucoma			++

Note: ++ absolutely contraindicated; + relatively contraindicated; 0 not contraindicated

CCTA Study Workflow

Purpose	Goal	Decrease HR and R-to-R variability Steady heart rate of 50-65 beats per minute (bpm)	Alternatives
A	Questionnaire Obtain baseline HR & BP	rule out contraindications if HR ≤ 65 bpm --> [D] if HR > 65 bpm --> [B]	
B	Oral Atenolol (Tenormin®)	100 mg p.o. 1-2 hour before cardiac CT if HR ≤ 65 bpm --> [D] if HR > 65 bpm --> [C]	CA Channel Blockers Oral Diltiazem (Cardizem®, regular release): 30 mg p.o. or doubling oral dose for patients currently taking oral calcium channel blockers
C	Intravenous Metoprolol (Lopressor®) injection with patient on the scanner table wait 3-4 min	5 mg i.v. slow injection over 1 min if HR ≤ 65 bpm --> [D] if HR > 65 bpm --> repeat [C] up to two times at 3-4 min interval maximal dosis: 15 mg Metoprolol (Lopressor®) if HR ≤ 65 bpm --> [D] if HR > 65 bpm --> [D] regardless of HR	OR if systolic BP>100 and HR>60 Intravenous Diltiazem (Cardizem Monovial ®): 10 mg i.v. over 2 min repeat 10 mg i.v. in every 10 min to maximal dosis of 40 mg
Purpose	Goal	coronary artery dilatation for better visualization	
D	Questionnaire Sublingual nitroglycerin (NitroQuick ®) wait 5 min	rule out contraindications 0.4 mg tablet --> [E]	Sublingual nitroglycerin spray (0.4 mg/L)
E	Scan	--> [F]	
F	Post scan monitoring HR & BP Recommendations	outpatients: for 30 min inpatients: on ward outpatients: 3h not operate machinery, i.e. driving car	

Calcium Score CT

Scan Technique

- Test inject saline first (Dual head injector)
- Practice breathing instructions
- 80 - 120 cc IV contrast
 - 30/70 chaser (R heart)
 - 30-50 mL saline chaser
- Bolus track / timing bolus



Reconstruction Technique

- Reconstructions:
 - ~ 1mm overlapping MPR
 - CPR, slice through display
 - Thin slab MIP
 - 0-90% R-R if retrospective (function or high HR)
- Review: 3D workstation, PACS



Post-CCTA Instructions

- **Outpatients:**
 - Observe ~30 min
 - No driving, etc. x 3 hr
- **Inpatients:**
 - Monitor on floor
- **ED:**
 - Disposition per ED rules



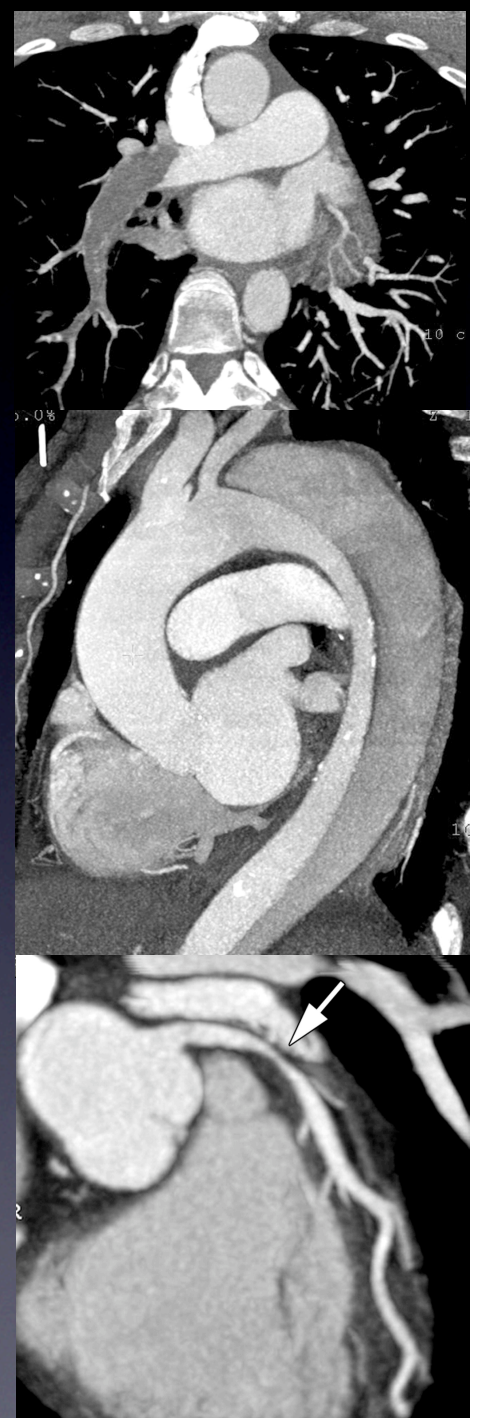
“Triple Rule Out” CTA

Primary goal of TRO CTA in the ED:

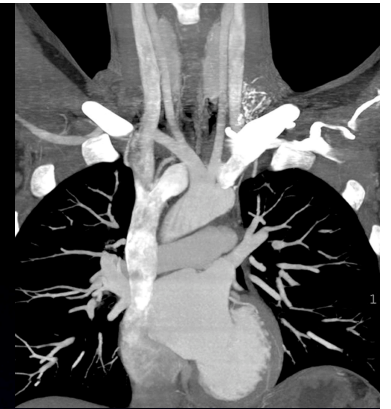
•To facilitate the safe, rapid discharge of patients judged to be at low to intermediate risk of acute coronary syndrome.

•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: Selection / Technique



- 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

β -blocker
NTG

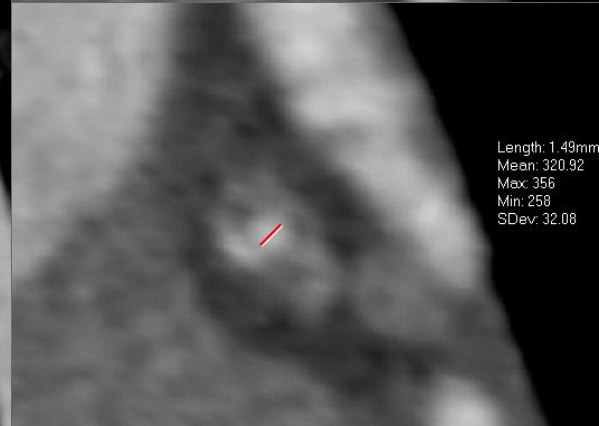
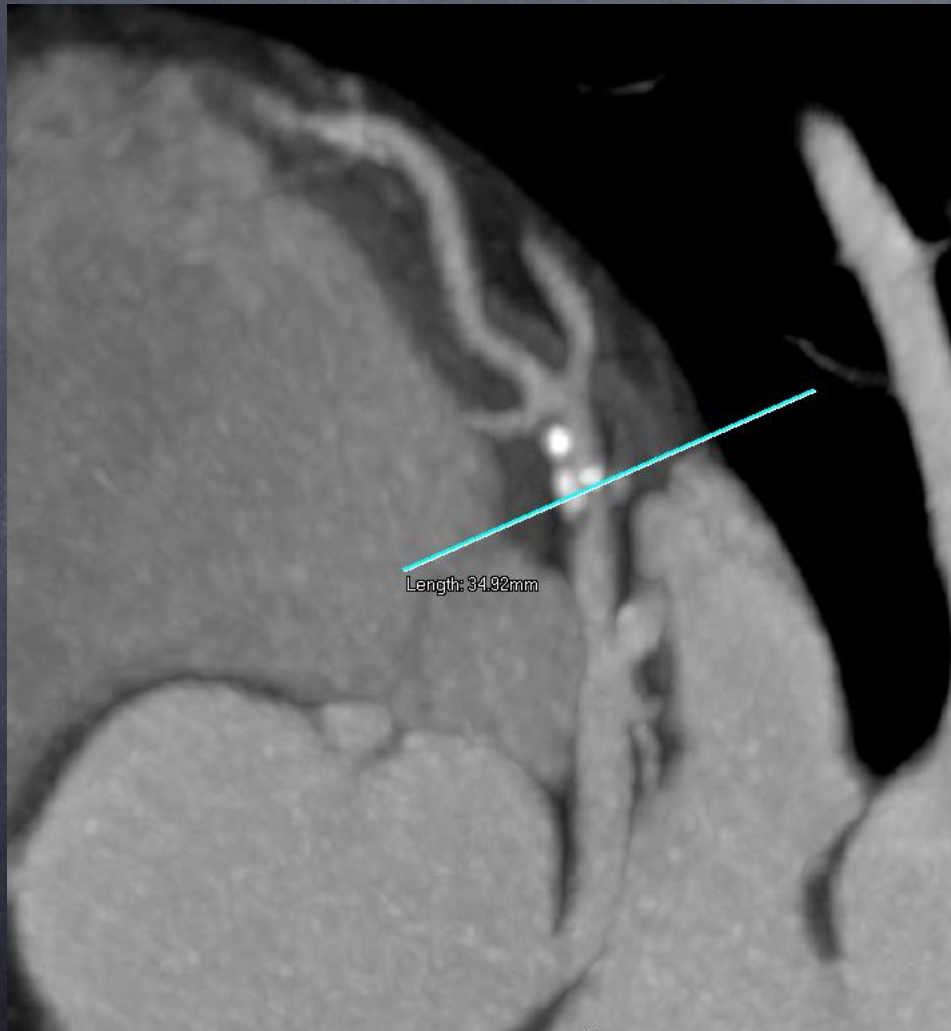
Longer Acquisition

Larger FOV

A little more contrast

A little more radiation

CCTA Results



Heart Rate

< 70 : 97% sens, 95% NPV

≥ 70 : 88% sens, 83% NPV

Calcium Score

≤ 100 : 94% sens, 95% NPV

≥ 400 : 93% sens, 67% NPV

Obesity

BMI ≤ 25 : 100% sens, spec, PPV, NPV

BMI ≥ 30 : 90% sens, 86% NPV

Indications /
Appropriateness for
CCTA

ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR Appropriate Use Criteria

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

CARDIAC COMPUTED TOMOGRAPHY WRITING GROUP

Allen J. Taylor, MD, FACC, FAHA, Chair*; Manuel Cerqueira, MD, FACC, FASNC†; John McB. Hodgson, MD, FACC, FSCAI‡; Daniel Mark, MD, MPH, FACC, FAHA*; James Min, MD, FACC§; Patrick O'Gara, MD, FACC, FAHA||; Geoffrey D. Rubin, MD, FSCBTMR¶#

TECHNICAL PANEL

Christopher M. Kramer, MD, FACC, FAHA, Moderator; Allen J. Taylor, MD, FACC, FAHA, Writing Group Liaison; Daniel Berman, MD, FACC§; Alan Brown, MD, FACC, FAHA, FNLA*; Farooq A. Chaudhry, MD, FACC, FAHA, FASE**; Ricardo C. Cury, MD§††; Milind Y. Desai, MD, FACC††; Andrew J. Einstein, MD, PhD, FACC, FAHA, FASNC‡; Antoinette S. Gomes, MD, FAHA, PSIR‡; Robert Harrington, MD, FACC, FAHA, FSCAI*; Udo Hoffmann, MD, MPH#; Rahul Khare, MD‡‡; John Lesser, MD, FACC§; Christopher McGann, MD, FACC§§; Alan Rosenberg, MD, FACC||; Robert Schwartz, MD, FACC‡; Marc Shelton, MD, FACC*; Gerald W. Smetana, MD¶¶; Sidney C. Smith, Jr, MD, FACC, FAHA||

ACCF APPROPRIATE USE CRITERIA TASK FORCE

Michael J. Wolk, MD, MACC, Chair; Joseph M. Allen, MA; Steven Bailey, MD, FACC, FSCAI; Pamela S. Douglas, MD, MACC, FAHA, FASE; Robert C. Hendel, MD, FACC, FAHA, FASNC; Christopher M. Kramer, MD, FACC, FAHA; James Min, MD, FACC, FSCCT; Manesh R. Patel, MD, FACC; Leslee Shaw, PhD, FACC, FASNC; Raymond F. Steinback, MD, FACC, FASE

*Official American College of Cardiology Foundation Representative.

†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.

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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>.

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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. | <ul style="list-style-type: none"> • ECG interpretable AND • Able to exercise • Intermediate pretest probability of CAD | A (7) |
| 2. | <ul style="list-style-type: none"> • ECG uninterpretable or unable to exercise • Low pretest probability of CAD | A (7) |
| 2. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • Normal ECG and cardiac biomarkers • Low pretest probability of CAD | A (7) |
| 6. | <ul style="list-style-type: none"> • Normal ECG and cardiac biomarkers • Intermediate pretest probability of CAD | A (7) |
| 7. | <ul style="list-style-type: none"> • ECG uninterpretable • Low pretest probability of CAD | A (7) |
| 7. | <ul style="list-style-type: none"> • ECG uninterpretable • Intermediate pretest probability of CAD | A (7) |
| 8. | <ul style="list-style-type: none"> • Nondiagnostic ECG or equivocal cardiac biomarkers • Low pretest probability of CAD | A (7) |
| 8. | <ul style="list-style-type: none"> • Nondiagnostic ECG or equivocal cardiac biomarkers • Intermediate pretest probability of CAD | A (7) |

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

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. | <ul style="list-style-type: none"> • Reduced left ventricular ejection fraction • Low pretest probability of CAD | A (7) |
| 13. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • Normal ECG exercise test • Continued symptoms | A (7) |
| 21. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • Discordant ECG exercise and imaging results | A (8) |
| 23. | <ul style="list-style-type: none"> • Stress imaging results: equivocal | A (8) |

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

Coronary CTA: Positive Stress Test

- Stress tests limited by high false positive rate of ST depression on ECG
- Stress echo and MPI have lower specificity in low - intermediate risk pts
- CCTA Cost-effective vs. direct referral to cath when (+) stress test and no Sx
 - especially when pre-test prob of CAD <50%

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)

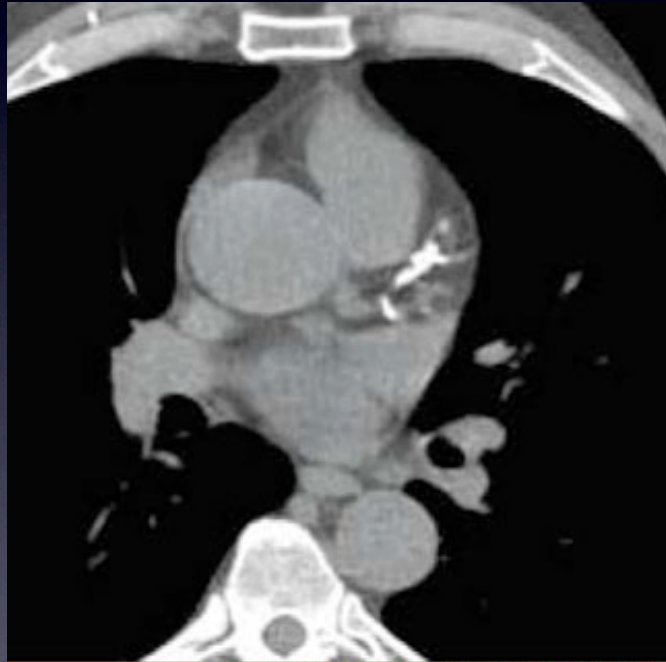
Taylor AJ, et al. Circulation
2010 vol. 122 (21) pp.
e525-55

Cardiac Structure and Function

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

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)

What about Calcium Scoring??



CAC: Technique

- Prospectively 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

Recent CAC Results

- Rotterdam Study¹:
 - CAC reclassified 52% intermediate 10-yr risk patients to low (<50) or high (>615) 10-yr risk
- Heinz Nixdorf Recall Study²:
 - CAC <100 and >400 reclassified ~ 20% of intermediate risk pts
- Colletti P, et al. Radiology 2010;257(1):64-70: Patients >75 YO
 - Higher CAC: higher rate of RWMA and lower EF at 10 yr

¹ Elias-Smale SE, et al. JACC 2010;56:1407-14

² Erbel R, et al. JACC 2010;56:1397-406

APPROPRIATENESS:

Coronary Calcium Scoring: ASYMPTOMATIC patients (ACCF/AHA)

- Patients with intermediate 10-year risk (Framingham, etc.) for CAD (10-20%)*
 - **Class IIa recommendation** (“is reasonable”)**
- Low to intermediate 10-year risk (6-10%)
 - **Class IIb** (“may be reasonable”)**
- Low 10-year risk (< 6%)**
 - **Class III** (“no benefit”)

* HENDEL RC et al. JACC 2006, 48(7): 1475-1497

** GREENLAND P et al. JACC 2010, 56(25): e50-103

Controversial Economics of Calcium Scoring

Coding / Billing



Coding / Billing

Calcium Scoring--CT (75571):

Heart without contrast material with quantitative evaluation of coronary calcium, **replaces 0144T**.
Not separately reportable with 75572, 75572, 75574.

Pulmonary Veins--CT (75572):

Heart with contrast material, for evaluation of cardiac structure and morphology (including 3D image post-processing, assessment of cardiac function and evaluation of venous structures, if performed). **Replaces 0145T**.

Congenital Heart Disease--CT (75573):

Heart with contrast material, for evaluation of cardiac structure and morphology in the setting of congenital heart disease (including 3D image post-processing, assessment of cardiac LV function, RV structure and function and evaluation of venous structures, if performed). **Replaces 0150T**.

CCTA--CT (75574):

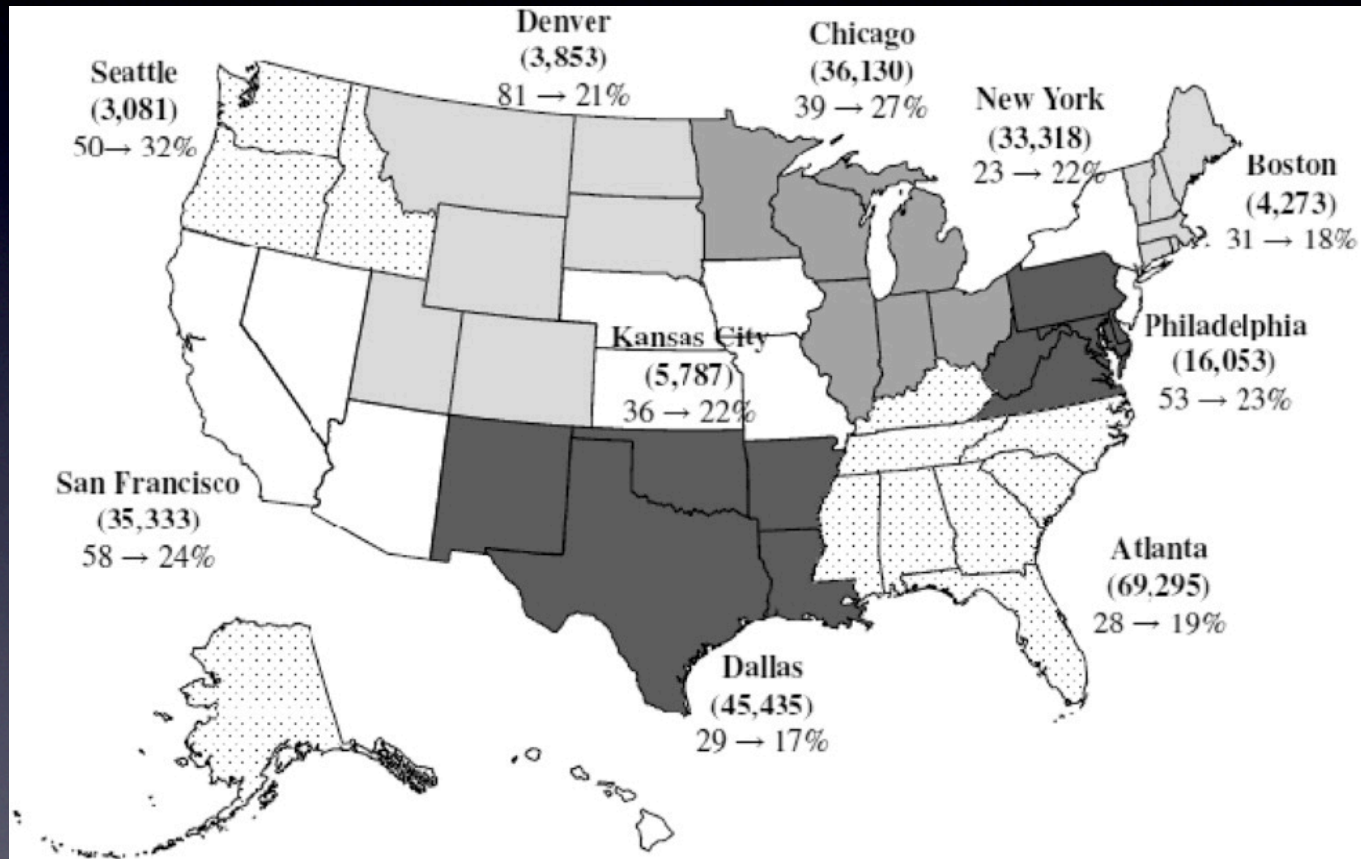
Heart, coronary arteries and bypass grafts (when present), with contrast material, including 3D image post-processing (including evaluation of cardiac structure and morphology, assessment of cardiac function and evaluation of venous structures, if performed). **Replaces 0146T-0149T**.

Medicare: LCD L25907

- CP syndrome: in lieu of initial stress imaging test
- Management of equivocal stress test
- Recurrent SX with known CAD- assess progression of Dz
- BPG assessment / large intracoronary stents
- Coronary anomalies (decide need / type of surgery)
- Coronary / Pulmonary venous mapping
- Pre-op for Non-coronary surgery- clearance
- ED patients w/ possible ischemia w/o Dx ECG or enzymes

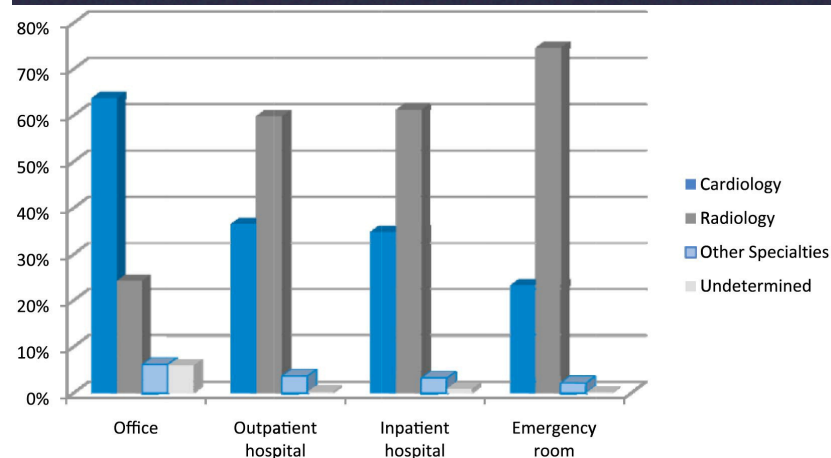
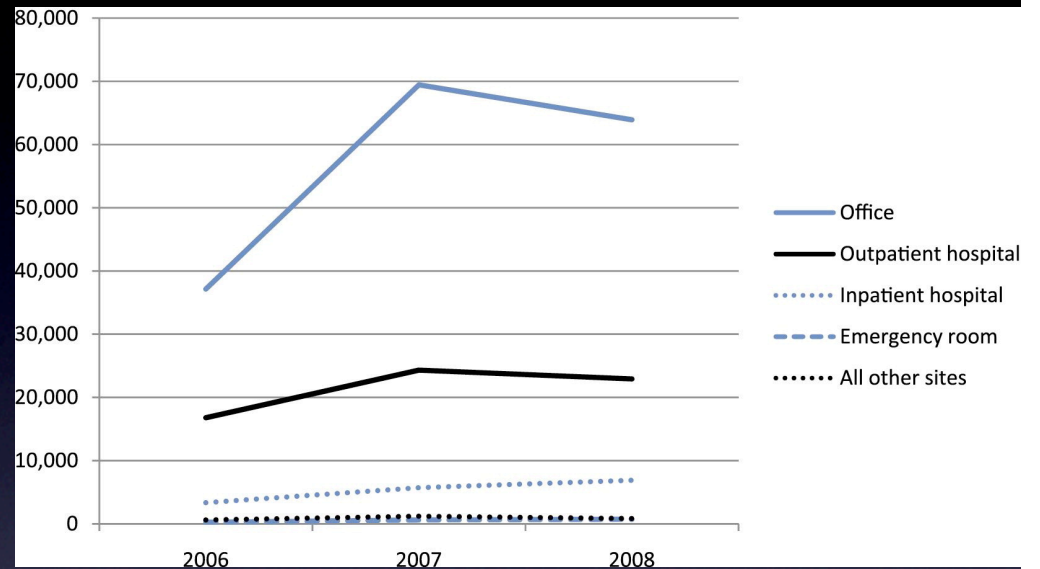
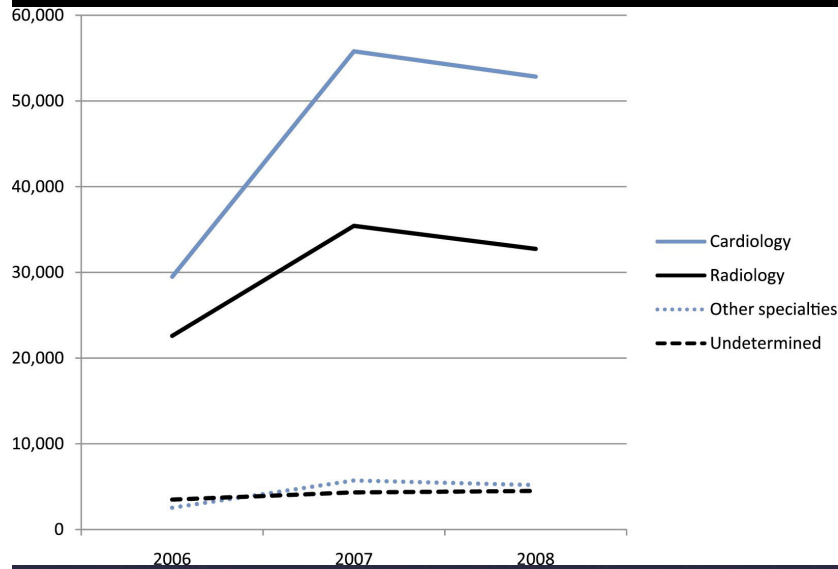
<http://www.cms.hhs.gov/medicare-coverage-database/details/lcd-details.aspx>

Trends in CCTA: 2006-2008



Duszak et al J ACR 2011 Aug;8(8):549-55.

Growth by specialty, location



Cardiologists: 54%
 Radiologists: 36%
 Other: 5%

3rd Party Carriers

- Often have their own ideas of “appropriateness” or medical necessity
- More information required
- Pre-authorization needed for some (most)
- Ironically, may result in more overall utilization

Example: CIGNA

CIGNA covers 64-slice or greater multidetector-row computed tomography angiography (CTA) as medically necessary as an adjunct to other testing for ANY of the following indications:

- evaluation of chest pain in an individual with a very low, low, or intermediate pre-test probability of coronary artery disease¹ (CAD) when the individual cannot perform or has a contraindication to exercise and chemical stress testing (i.e. exercise treadmill stress test, stress echo, and nuclear stress test [i.e., myocardial perfusion imaging])
- exclusion of CAD in an individual with a low or very low pre-test probability of CAD when recent stress test results (i.e., exercise treadmill, stress echo, or nuclear stress test [i.e., myocardial perfusion imaging]) are uninterpretable, equivocal, or there is a suspicion that the results are falsely positive
- exclusion of CAD in an individual with an intermediate pre-test probability of CAD when recent stress test results (i.e., exercise treadmill, stress echo, or nuclear stress test [i.e., myocardial perfusion imaging]) are uninterpretable or equivocal, AND CTA will be performed in lieu of an angiography.
- exclusion of CAD in a symptomatic individual (e.g., acute chest pain in an emergency department setting), and the individual has an intermediate pre-test probability of CAD, and there are no changes noted on the ECG and serial enzymes are negative
- evaluation of suspected or known coronary artery anomalies associated with congenital conditions
- for morphologic evaluation of the coronary arteries in an individual with dilated cardiomyopathy or new onset heart failure, when ischemia is the suspected etiology and cardiac catheterization and/or nuclear stress test (i.e., myocardial perfusion imaging) have not been performed
- pre-operative assessment of coronary arteries in an individual undergoing repair of aortic dissection, aortic aneurysm repair or valvular surgery AND CTA will be performed in lieu of an angiography
- post-coronary artery bypass grafting (CABG) when BOTH of the following criteria are met:
 - repeat intervention is being considered
 - recent coronary angiography has been completed but additional information is needed before a treatment decision can be made

CIGNA: ICD9 (Diagnosis) Codes

ICD-9-CM Diagnosis Codes	Description
411.1 [†]	Intermediate coronary syndrome
413.0-413.9 [†]	Angina Pectoris
414.01 [†]	Coronary atherosclerosis of native coronary artery
414.9 [†]	Unspecified chronic ischemic heart disease
415.11-415.19	Pulmonary embolism
428.0 [†]	Congestive heart failure, unspecified
428.1 [†]	Left heart failure
428.9 [†]	Unspecified heart failure
430	Subarachnoid hemorrhage
431	Intracerebral hemorrhage
432.0-432.9	Other intracranial hemorrhage
433.00 – 433.91	Occlusion and stenosis of precerebral arteries
434.00 – 434.91	Occlusion of cerebral arteries
435.0 – 435.9	Transient cerebral ischemia
436	Acute but ill-defined cerebrovascular disease
437.0 – 437.9	Other and ill-defined cerebrovascular disease
440.0 – 440.9	Atherosclerosis
441.0 – 441.9	Aortic aneurysm and dissection
442.0 – 442.9	Other aneurysm
443.0 – 443.9	Other peripheral vascular disease
444.0 – 444.9	Arterial embolism and arthrosis
746.0-746.9	Other congenital anomalies of the heart
747.0 – 747.9	Other congenital anomalies of the circulatory system
786.50 [†]	Unspecified chest pain

[†] **Note:** These indications are covered only if performed using 64-slice CT

Aetna CCTA Appropriateness

- Rule out significant coronary stenosis in persons with a **low or very low pre-test probability** of coronary artery disease by Framingham risk scoring or by American College of Cardiology criteria (see Appendix), with any of the following indications:
 - Evaluation of persons with chest pain who can not perform or have contraindications to exercise and pharmacological stress testing (see Appendix); *or*
 - Evaluation of persons with a positive (i.e., greater than or equal to 1 mm ST segment depression) exercise stress test; *or*
 - Evaluation of persons with chest pain presenting to the emergency department when an imaging stress test or coronary angiography are being deferred as the initial imaging study.
- Evaluation of asymptomatic persons at low pretest probability of coronary heart disease by Framingham risk scoring (see Appendix) who have an equivocal exercise or pharmacological stress test. Note: Current guidelines from the American Heart Association recommend against routine stress testing for screening asymptomatic adults.
- Pre-operative assessment of persons scheduled to undergo "high-risk" non-cardiac surgery, where an imaging stress test or invasive coronary angiography is being deferred unless absolutely necessary. The American College of Cardiology defines high-risk surgery as emergent operations, especially in the elderly, aortic and other major vascular surgeries, peripheral vascular surgeries, and anticipated prolonged surgical procedures with large fluid shifts and/or blood loss involving the abdomen and thorax.
- Pre-operative assessment for planned non-coronary cardiac surgeries including valvular heart disease, congenital heart disease, and pericardial disease, in lieu of cardiac catheterization as the initial imaging study.
- Detection and delineation of suspected coronary anomalies in young persons (less than 30 years of age) with suggestive symptoms (e.g., angina, syncope, arrhythmia, and exertional dyspnea without other known etiology of these symptoms in children and adults; dyspnea, tachypnea, wheezing, periods of pallor, irritability (episodic crying), diaphoresis, poor feeding and failure to thrive in infants).

Aetna “Exclusions”

Aetna considers cardiac CT angiography experimental and investigational for persons with any of the following contraindications to the procedure:

- Body mass index (BMI) greater than 40.
- Inability to image at desired heart rate (under 80 beats/min), despite beta blocker administration.
- Person with allergy or intolerance to iodinated contrast material
- Persons in atrial fibrillation or with other significant arrhythmia.
- Persons with extensive coronary calcification by plain film or with prior Angston score greater than 1700.
- Aetna considers coronary CT angiography experimental and investigational for screening of asymptomatic persons, evaluation of atherosclerotic burden, evaluation of persons at intermediate or high pretest probability of coronary artery disease, evaluation of stent occlusion or in-stent restenosis, evaluation of persons with an equivocal PET rubidium study, identification of vulnerable plaques, monitoring of atheroma burden, **and for all other indications.**
- Aetna considers cardiac CT angiography using less than 64-slice scanners experimental and investigational.
- Aetna considers calcium scoring by means of low-dose CT angiography medically necessary for diagnostic cardiac CT angiography to assess whether an adequate image of the coronary arteries can be obtained.
- **Aetna considers calcium scoring (e.g., with ultrafast [electron-beam] CT, spiral [helical] CT, and multi-slice CT) experimental and investigational for all other indications because the definitive value of calcium scoring for assessing coronary heart disease risk has not been established in the peer-reviewed published medical literature.**

http://www.aetna.com/cpb/medical/data/200_299/0228.html

CODING AND BILLING PERSONNEL HIGHLY RECOMMENDED!!

Logistics of Cardiac CT in the “Real World”

- ◆ Turf Issues
- ◆ Clinical Implementation / Adoption
- ◆ Study Acquisition / Reconstruction
- ◆ Workflow
- ◆ Study Interpretation

Online Handouts from Lecture:

www.stanford.edu/~hallett

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“Turf” in CVI

- ◆ **Every situation is different**
- ◆ **Training requirements**
- ◆ **Call responsibilities**
- ◆ **Monetary issues**

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NWR Situation

- ◆ Heart Center of Indiana (HCI) initially built and owned by cardiologists and CV surgeons
- ◆ Fellowship-trained cardiologist reads CMRI, PV mapping, etc
 - ◆ Also does nucs, clinical work
- ◆ NWR reads most everything else at HCI
 - ◆ Calcium scores also (20/day)
- ◆ NWR reads all CTA/MRA at other sites
- ◆ Good communication; shared expertise and collaboration

10.00mm/div

10.00mm/div

Other Situations

- ◆ Unique to each place
- ◆ Try to reach common ground
- ◆ **COLLABORATE FOR BEST CARE**
 - ◆ Shared billing / Lease arrangements in IR
- ◆ Hospitals interested in patient satisfaction, volume, and \$\$ bottom line, not as much in feelings or perceived quality

10.00mm/div

Implementation and Adoption of Cardiac CT: Practical Issues

CCTA is disruptive technology

- Referring MDs very busy - won't spend much time to change workflow for disruptive technology like CCTA
- Turn-around time (TAT) must be rapid, especially to ED
- Have to be able to provide 24/7 coverage if doing ED patients
- To be successful, need to spend time/\$\$ for MD/RT/ clinician education, CME, in-services, decision support to build referral base

Streamlining Clinical Decision-Making

- 2007: Laminated “Cheat Sheet” given to ED and referring MDs
 - CME talks given at each hospital
- 2011: Revised Cheat Sheet after new guidelines
- 24/7 NWR Imaging Assistant
- “Structured” Reporting / Wet Read Sheet
- Pre-printed order sheets, Pt. prep instructions

APPROPRIATE INDICATIONS: CORONARY AND CARDIAC CT (2011)

CLINICAL SCENARIO	FOR THESE INDICATIONS:	ORDER THIS:
SYMPTOMATIC, NONACUTE SX (? Ischemic Eq.) NO KNOWN Heart Disease	<ul style="list-style-type: none"> •LOW Pre-test Probability: ECG uninterpretable OR unable to exercise •INTERMEDIATE Pre-Test Probability (+/- ECG interpretable, can exercise) 	CCTA
SYMPTOMATIC, ACUTE SX (Urgent Presentation) NO KNOWN Heart Disease	LOW OR INTERMEDIATE: <ul style="list-style-type: none"> •Normal ECG and biomarkers OR ECG uninterpretable OR ECG / biomarkers non-diagnostic 	CCTA
PRIOR TEST RESULTS	<ul style="list-style-type: none"> •NORMAL STRESS ECG TEST WITH CONTINUED SX; DUKE TREADMILL SCORE INTERMEDIATE RISK •NEW/WORSENING SX , PREVIOUS NORMAL STRESS IMAGING STUDY •DISCORDANT OR EQUIVOCAL STRESS ECG AND IMAGING RESULTS 	CCTA
SYMPTOMATIC	Evaluate suspected CORONARY ANOMALIES	CCTA
NEW DX OR ONSET HEART FAILURE (NO PRIOR CAD)	LOW OR INTERMEDIATE RISK patients with reduced EF	CCTA
CARDIAC MASS / THROMBUS / VALVULAR DISEASES / PERICARDIAL EVAL. CONGENITAL HEART DISEASE	<ul style="list-style-type: none"> •If limited info from Echo, TEE, or MRI (problem solving) •STRUCTURE AND FUNCTION 	Cardiac CT
RISK ASSESSMENT POST PCI OR CABG	<ul style="list-style-type: none"> •SYMPTOMATIC (ISCHEMIC EQUIVALENT) : EVALUATE GRAFT PATENCY •Prior to Re-Do CABG (assess positions and patency of bypass grafts- esp. LIMA) 	CTA CHEST- BYPASS GRAFT
	ASYMPTOMATIC, PRIOR LEFT MAIN STENT (> 3mm)	CCTA
CORONARY CALCIUM SCORE	<ul style="list-style-type: none"> •INTERMEDIATE 10-YEAR RISK FOR CHD EVENTS (FRS = 10-20%) •LOW 10-YEAR RISK BUT FAMILY HISTORY OF PREMATURE CHD 	CAC SCORE
CONTRAINDICATIONS to CORONARY CTA: (MOST ARE RELATIVE)	<ul style="list-style-type: none"> •Weight >300 lbs •Calcium Score >500 •Iodine (Contrast) allergy (and not pre-medicated) •Contraindication to B-blocker, NTG •Severe Asthma or COPD •AFIB <p align="right"> FRAMINGHAM RISK CALCULATOR: http://www.mdcalc.com/framingham-cardiac-risk-score </p>	

From: 1. Taylor AJ, et al. Circulation 2010; 122(21) e525-55.
2. Greenland P, et al. JACC 2007 49(3): 378-402

NWR Imaging Assistant: 317-328-5058

CCTA Reporting Form

Name: _____

MRN: _____

Northwest Radiology Network
Coronary CTA Preliminary Interpretation

Study Date ___/___/___
mo day year

FACILITY: _____

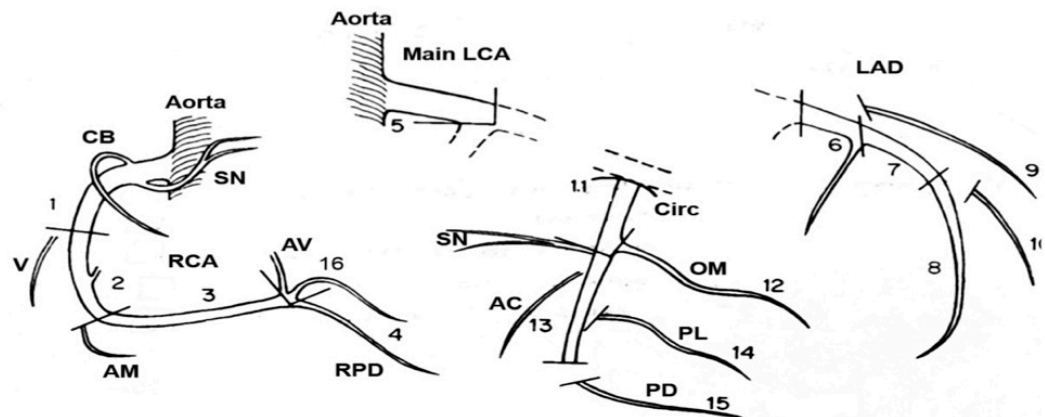
RADIOLOGIST: _____

TIME OF WET READ: _____

CALCIUM SCORE: _____

OTHER FINDINGS:

FINDINGS	
Vessel segment	Stenosis or Occlusion
RCA	
PROX (1)	
MID (2)	
DISTAL (3)	
PDA (4)	
LEFT MAIN (5)	
LAD	
PROX (6)	
MID (7)	
DISTAL (8)	
DIAG1 (9)	
DIAG2 (10)	
LCX	
PROX (11)	
OM1 (12)	
DISTAL (13)	
OM2 (14)	
PDA (15)	
RAMUS (17)	
Other _____	



Cardiac CT Order Form

Patient Name: _____

DOB: ____/____/____

Sex: Male Female

75572 - CCTA Cardiac Structure and Venous



75574 - CCTA of the Coronary Arteries



75574 - CCTA of the Coronary Arteries and Veins



75573 - CCTA - Structure / Morphology in Congenital Heart



MISCELLANEOUS:

75571 Calcium Score ONLY

Diagnoses:

CCTA w/Morphology

- 427.31 Atrial Fibrillation
- 427.32 Atrial Flutter
- 427.41 Ventricular Fibrillation
- 427.42 Ventricular Flutter
- V72.81 Pre-Op CVD Exam

CCTA of Coronary Arteries

- ___ 411.1 Angina (unstable, pre-infarction, progressive)
- ___ 412 Old Myocardial Infarct
- ___ 413.0 Angina Decubitus
- ___ 413.1 Prinzmetal Angina
- ___ 413.9 Angina (stable, exertional)
- ___ 414.00 CAD Unspec. Vessel
- ___ 414.01 ASHD Native
- ___ 414.02 CAD auto vein graft
- ___ 414.03 CAD non-auto graft
- ___ 414.04 CAD artery graft
- ___ 414.05 ASHD Bypass, NOS
- ___ 414.06 ASHD coronary artery of Transplanted Heart
- ___ 414.10 Aneurysm of Heart Wall
- ___ 414.11 Aneurysm of cor Vessels
- ___ 414.12 Aneurysm of cor Artery
- ___ 414.19 Other Aneurysm of Heart
- ___ 414.8 Ischemic Cardiomyopathy
- ___ 424.1 Aortic Valve Disorders
- ___ 786.05 Shortness of Breath
- ___ 786.50 Unspec. Chest Pain
- ___ 786.51 Precordial Pain
- ___ 786.59 Other Chest Pain
- ___ 794.30 Unspec. Abnormal Function Study of CV System
- ___ 794.31 Abnormal ECG
- ___ V72.81 Pre-Op CVD Exam

CCTA Coronary Arteries + Veins

- ___ 411.1 Angina (unstable, pre-infarction, progressive)
- ___ 412 Old Myocardial Infarct
- ___ 413.0 Angina Decubitus
- ___ 413.1 Prinzmetal Angina
- ___ 413.9 Angina (stable, exertional)
- ___ 414.00 CAD Unspec. Vessel
- ___ 414.01 ASHD Native
- ___ 414.02 CAD auto vein graft
- ___ 414.03 CAD non-auto graft
- ___ 414.04 CAD artery graft
- ___ 414.05 ASHD Bypass, NOS
- ___ 414.06 ASHD coronary artery of Transplanted Heart
- ___ 414.10 Aneurysm of Heart Wall
- ___ 414.11 Aneurysm of cor Vessels
- ___ 414.12 Aneurysm of cor Artery
- ___ 414.19 Other Aneurysm of Heart
- ___ 414.8 Ischemic Cardiomyopathy
- ___ 424.1 Aortic Valve Disorders
- ___ 786.05 Shortness of Breath
- ___ 786.50 Unspec. Chest Pain
- ___ 786.51 Precordial Pain
- ___ 786.59 Other Chest Pain
- ___ 794.30 Unspec. Abnormal Function Study of CV System
- ___ 794.31 Abnormal ECG
- ___ V72.81 Pre-Op CVD Exam

CCTA of Congenital Heart

- ___ 745.12 L Transposition
- ___ 745.2 Tetralogy of Fallot
- ___ 745.3 Single Ventricle
- ___ 745.4 VSD
- ___ 745.5 Atrial Septal Defect
- ___ 745.61 ASD Primum
- ___ 745.69 AV Canal
- ___ 745.9 Unspec. Defect of Septa Closure
- ___ 746.2 Ebsteins Anomaly
- ___ 746.3 Aortic Stenosis
- ___ 746.4 Ao Insuff, Congen Valve
- ___ 746.6 Mitral Stenosis, Congen
- ___ 746.6 Mitral Insuff, congen
- ___ 746.7 Hypoplastic LH
- ___ 746.81 Aub-Ao Stenosis
- ___ 746.82 Cor Triatriatum
- ___ 746.83 Infundibular PS
- ___ 746.85 Cor Art Anomaly
- ___ 746.86 Congenital Heart Block
- ___ 746.87 Dextrocardia
- ___ 747.0 PDA
- ___ 747.41 Tot Anomaly Pulm Vein
- ___ 747.42 Partial Anom Pulm Vein
- ___ 747.49 Other Anomalies Veins

Other: _____

Patient Preparation / Info

Cardiac CT Patient Prep Form

ORDERING PHYSICIAN SIGNATURE: _____

Please fax the following information to
 (317) 583-5425 before the date of the exam:

_____ dosage of Beta Blockers

_____ Heart Rate _____ Blood Pressure

_____ BUN _____ CR
 (less than one month old)

Test Date:

Time:

The Heart Center of Indiana
 10580 N. Meridian
 Indpls., IN 46290
 (317) 583-5151
 (317) 583-5425 FAX

APPROPRIATE INDICATIONS

- Chest Pain Syndrome -**
- Intermediate pre-test probability + abnormal ecg OR unable to exercise
 - Patient with equivocal stress test
 - Evaluation of suspected coronary anomalies
- Heart Failure -** New onset heart failure, assess etiology
- Electrophysiology -**
- Pulmonary veins prior to ablation for atrial fibrillation
 - Coronary vein mapping prior to bi-ventricular pacing
- Congenital -** Evaluate congenital heart disease
- Other Indication -** _____

INTERMEDIATE PRE-TEST PROBABILITY: (2002 ACC/AHA Criteria)

- Any Male > 30 with atypical symptoms
- Any Male > 40 with non-anginal chest pain
- Any Female > 50 w/atypical Symptoms
- Any Female between 30 - 50 with typical Symptoms

PATIENT PREPARATION

- Beta Blocker:** HR < 50 BPM, No B-Blocker
 HR 50 - 75 BPM - 50 mg Metoprolol
 HR 75 - 90 BPM - 100 mg Metoprolol
 Administered 2 hours prior to appointment, **unit doses of Metoprolol available in MOB/NAAB offices.**
- No caffeine, tobacco or alcohol for 24 hours prior to test.
- No erectile dysfunction (Viagra, Cialis, etc.) medications for 48 hours prior to test.
- Instruct patient to drink 3 - 5 glasses of water prior to the test.
- Please obtain a BUN and Creatinine for patients with renal insufficiency and pre-medicate patients with contrast allergy (Prednisone 60 mg, Benadryl 50 mg the evening before and morning of the test).

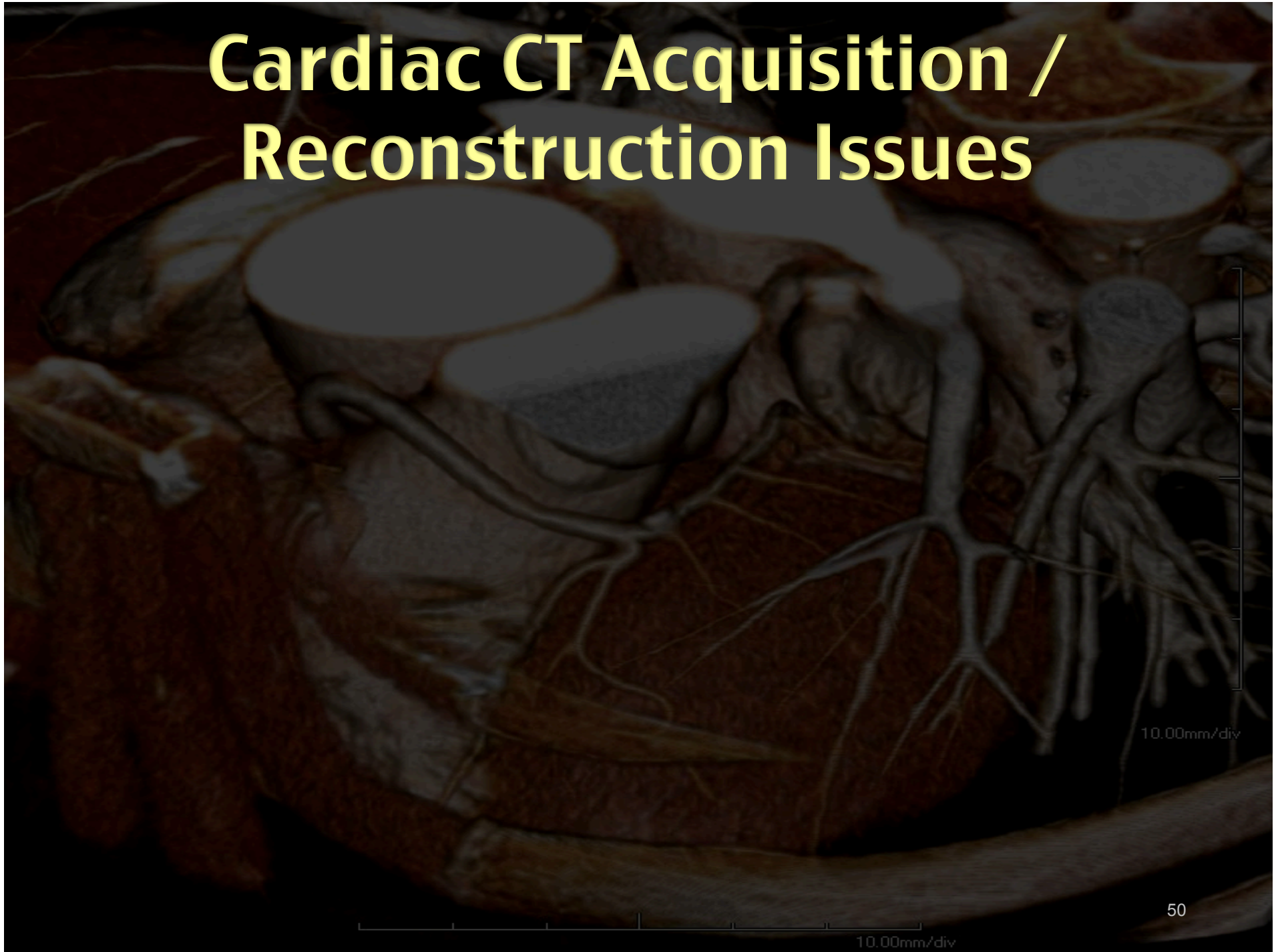
NON-OPTIMAL CONDITIONS FOR CORONARY CTA

- Atrial fibrillation or frequent ectopy.
- Resting tachycardia (> 90 BPM)
- Chronic renal insufficiency (GFR < 30)
- Extreme obesity (>38 kg/m²)
- Intolerant of Beta-Blockers

Referring Physician: _____

Fax number for results: _____

Cardiac CT Acquisition / Reconstruction Issues



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Study Acquisition / Reconstruction Challenges

- ◆ **Standardize Protocols Across Enterprise**
 - ◆ 17 hospitals / 10 imaging centers
 - ◆ All CT vendors; 10–256 DCT
 - ◆ Wide variation in pt. sizes
 - ◆ Varying technologist knowledge base and motivation

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Study Acquisition / Reconstruction Challenges

- ◆ **Standardize Protocols Across Enterprise**
 - ◆ **Separate protocols generated for each scanner, available on "G Drive" and via Imaging Assistant**
 - ◆ **Standard Recon Protocols (modify for scanner specifics)**
 - ◆ **Weight-based dosing (Medrad P3T or calculated)**
 - ◆ **24/7 NWR Imaging Assistant to locate info and expertise**
 - ◆ **In-service for RT knowledge, result feedback to RTs**
 - ◆ **CE credits**
 - ◆ **NWR Desktop for review of previous studies**

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Cardiac CT Workflow



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Goals of CCTA workflow

- Process studies efficiently
- Capture all appropriate charge codes
- Provide access to thin-slice datasets for interpretation and review
- Provide timely reports to referring clinicians / services

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10.00mm/div

CCTA Workflow Problems.....

- ◆ **LARGE number of images**
- ◆ **Studies done at many locations**
- ◆ **Time constraints to interpretation**

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Coordinated Workflow Yield Best Results (think Ultrasound!)

◆ **Physician-directed:** primary interpretation

◆ Volumetric Interpretation via:

- ◆ Workstation
- ◆ Thin Client – Server (real-time consults)
- ◆ PACS
- ◆ Output via call, email, send back to PACS

◆ **Technologists:** protocol-driven recons, measurements, documentation

- ◆ **3D Laboratory**

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NWR Solution

- ◆ Thin-Client solution in-house at most larger hospitals for interpretation
- ◆ Some have dedicated workstations
 - ◆ Often not where needed!
- ◆ Techs produce: calcium score, CPRs, function, LFOV lung windows, thin axials → **PACS**
- ◆ Interactive 3D review of thin-slice datasets by MD

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Interpretation Strategies

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What is An Effective Platform for Interpretation?

- ◆ ***Fast and available***
- ◆ ***Easy Import/Export DICOM data***
- ◆ ***Simultaneous review of various phases / Cine***
- ◆ ***Comparison of prior exams***
- ◆ ***Ergonomic***
 - ◆ ***minimize hand motion/clicks***
 - ◆ ***mouse controlled***
 - ◆ ***avoid deep menus***

Platform Options

◆ *Dedicated workstation*

- + Most features, high performance
- Local availability only, relatively expensive

◆ *Software running on standard PC*

- + Distributed (depends on pricing), relatively inexpensive
- Less features, lower performance

◆ *Server-Client*

- + Distributed, low cost per “workstation”
- Less features, performance is network dependent

◆ *“Cloud”*

- + No client to download, multiple platforms (iPad, iPhone, etc.)
- Security needs, performance is internet dependent

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60
60

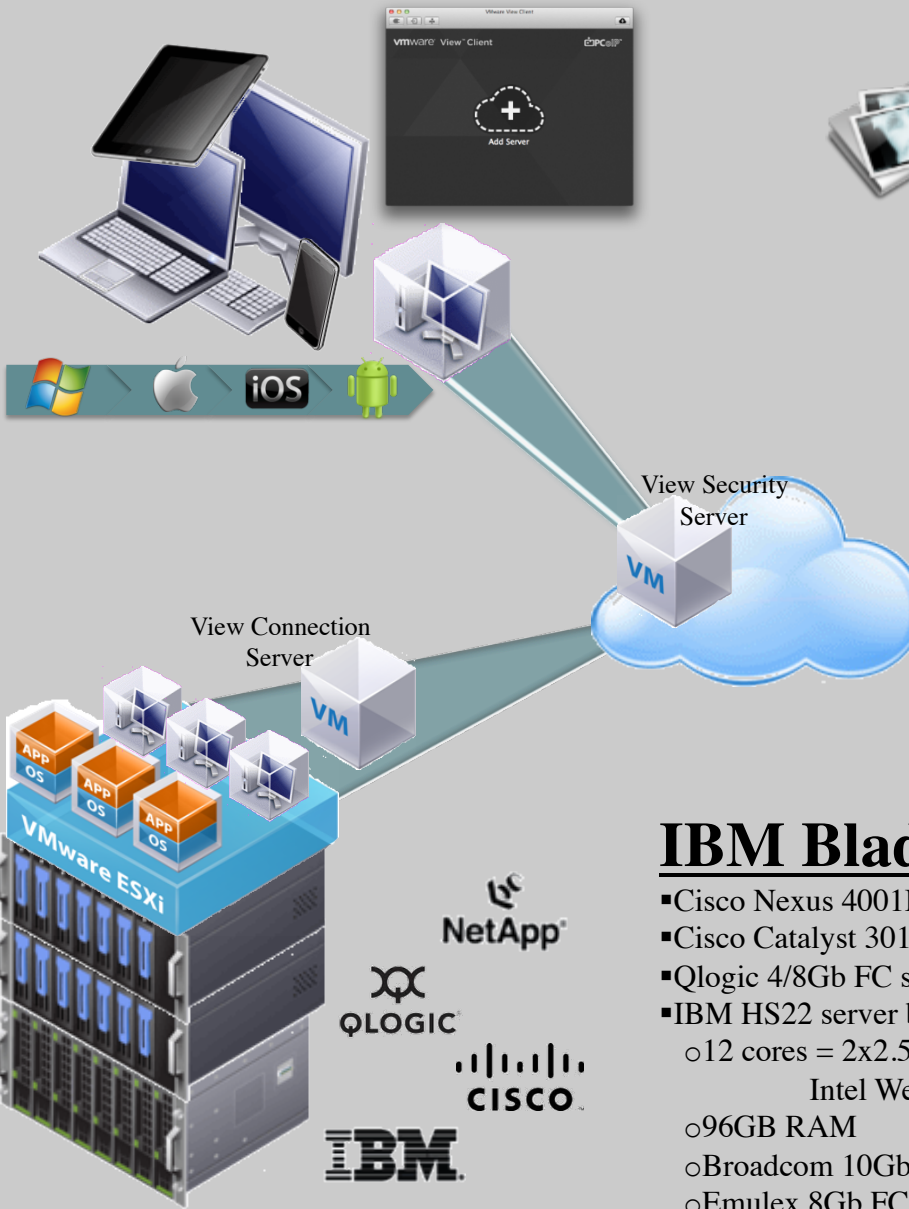
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NWR Solution

- ◆ **“Virtual” desktop: access from desktop, laptop, iPad, iPhone, Android**
- ◆ **Single access to Desktop allows user to access:**
 - ◆ **3 PACS systems**
 - ◆ **3 Terarecon AQNET systems**
 - ◆ **2 GE AW workstations**
 - ◆ **Stat-Dx**
 - ◆ **NWR Protocols**
 - ◆ **NWR Schedules**

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VIRTUAL DESKTOP



Applications Delivered

- Multiple PACS
- Multiple TeraRecon
- PowerScribe (review only)
- RadPeer
- Reference Materials
- Physician Scheduling
- Microsoft Office
- Internally Developed
NWR launchPAD
 launchPad
 Simplified Sign on System



IBM BladeCenter H

- Cisco Nexus 4001I switch x 2
- Cisco Catalyst 3012 switch x 2
- Qlogic 4/8Gb FC switch x 2
- IBM HS22 server blade x 7
 - 12 cores = 2x2.53GHz Intel Westmere
 - 96GB RAM
 - Broadcom 10GbE
 - Emulex 8Gb FC

Storage

- Virtual Servers = IBM DS3524
- Virtual Desktops = NetApp FAS2040





launchPad

Don't Double Click ? X & Power

Monday, April 16, 2012
1:32:42 PM EDT

Clinical Applications

- NWR RIS/PACS
- STV PACS
- Witham PACS
- TeraRecon
- NWR PowerScribe (review only)
- RadPeer
- Reference Materials

Productivity Applications

- NWR Portal
- Physician Schedule
- Outlook
- Word
- Excel
- PowerPoint

Utilities

- Internet Explorer
- SimplifiedSignOn Maintenance
- Home Folder
- Group Folders
- Bomgar (remote control)

click icons once uses simplified sign on secondary screen will launch uses integrated authentication

How I read CCTA....

- Read from thin client whenever possible
- VR then axial overview, STS MIP/MPR interactively
- Measurements from MPR (orthogonal, etc)
- My pertinent images - sent to PACS as a series
- All ED and stat CCTA results called
- Simple reporting form for ED cases (can serve as wet-read)
- Web-based "consult" features of 3D client

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CCTA Reporting Form

Name: _____

MRN: _____

Northwest Radiology Network
Coronary CTA Preliminary Interpretation

Study Date ___/___/___
mo day year

FACILITY: _____

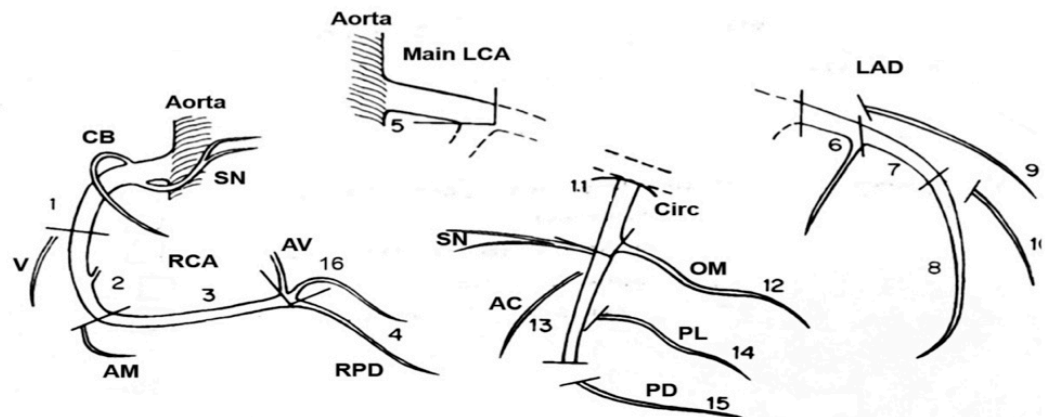
RADIOLOGIST: _____

TIME OF WET READ: _____

CALCIUM SCORE: _____

OTHER FINDINGS:

FINDINGS	
Vessel segment	Stenosis or Occlusion
RCA	
PROX (1)	
MID (2)	
DISTAL (3)	
PDA (4)	
LEFT MAIN (5)	
LAD	
PROX (6)	
MID (7)	
DISTAL (8)	
DIAG1 (9)	
DIAG2 (10)	
LCX	
PROX (11)	
OM1 (12)	
DISTAL (13)	
OM2 (14)	
PDA (15)	
RAMUS (17)	
Other _____	



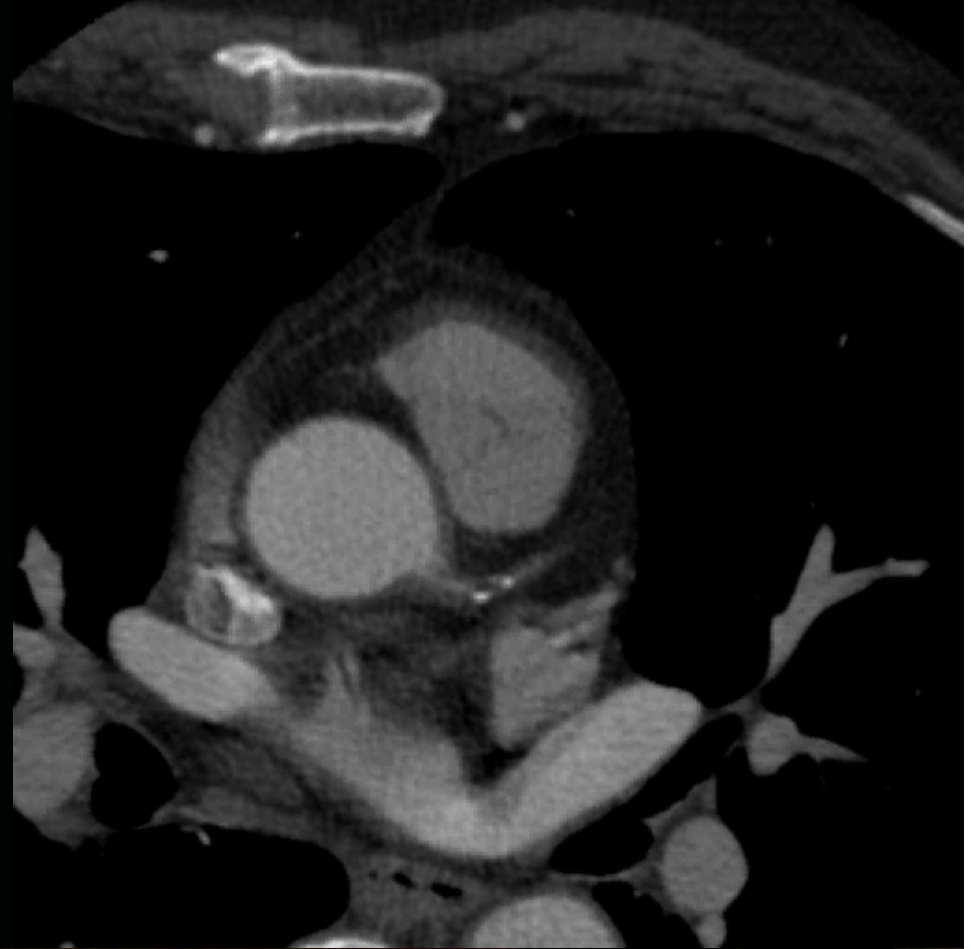
A Recent Case Study

- ◆ 69 yo Male, equivocal stress nuclear
- ◆ Contrast allergy
- ◆ Hx of “bleeding disorder”

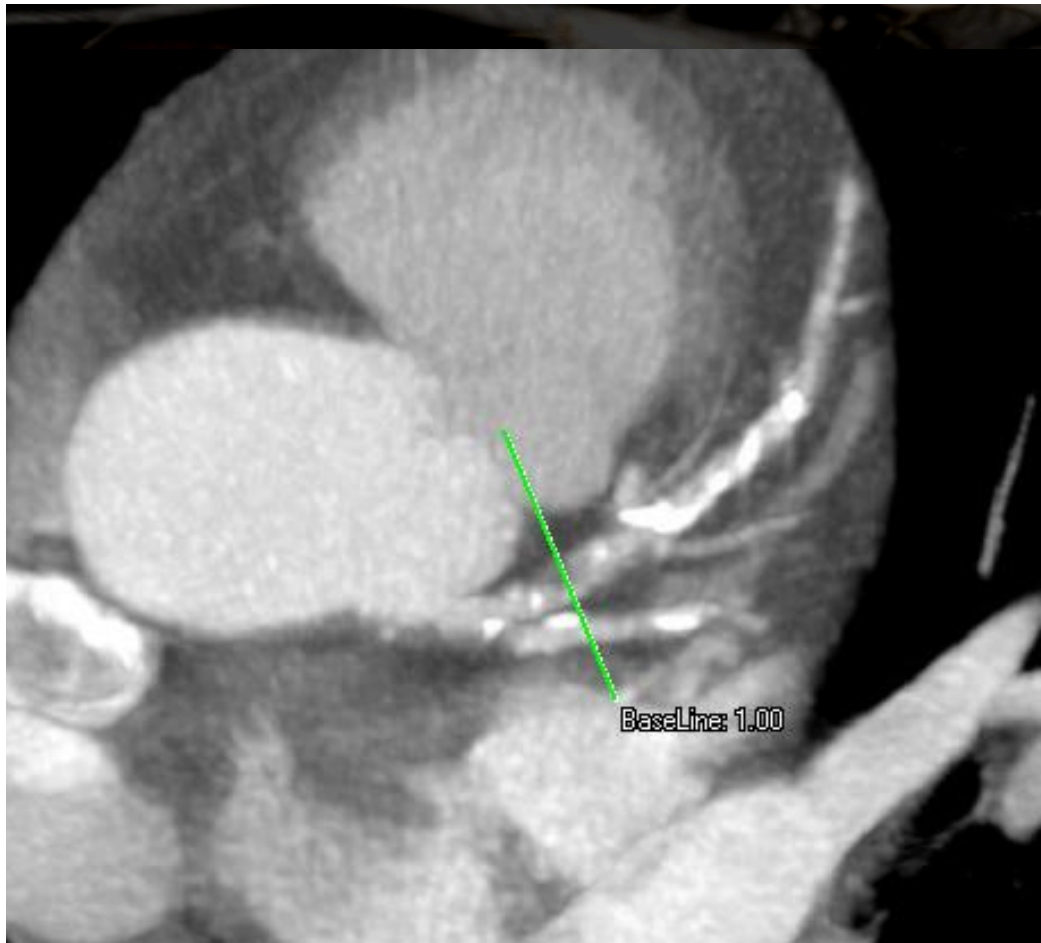
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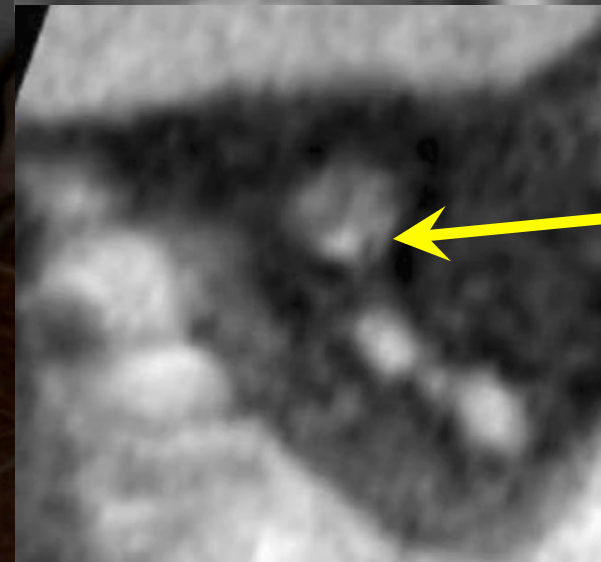
VR Overview



Interactive MPR



Minimal lumen = 1 mm
Normal segment = 3.2 mm
~ 65% diameter reduction



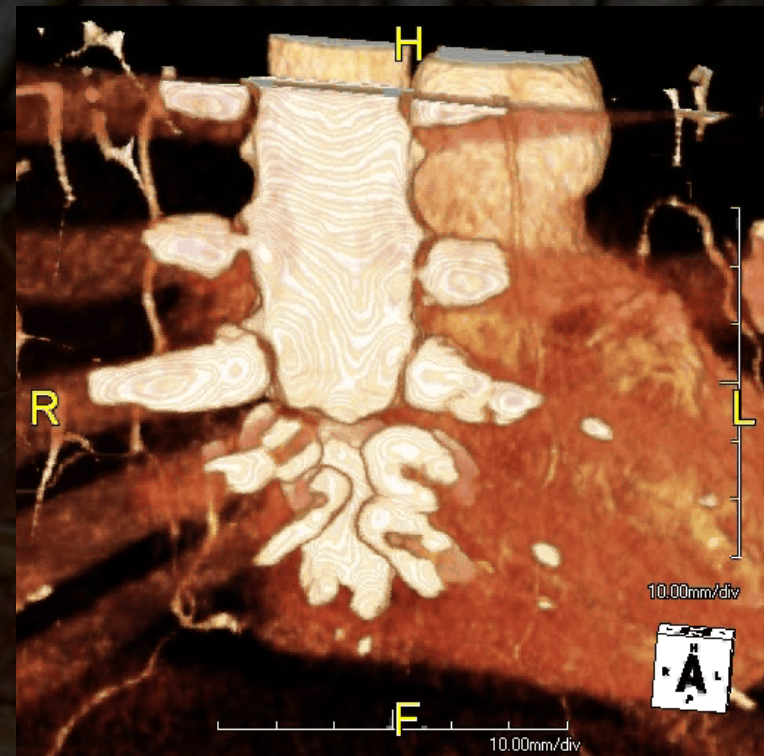
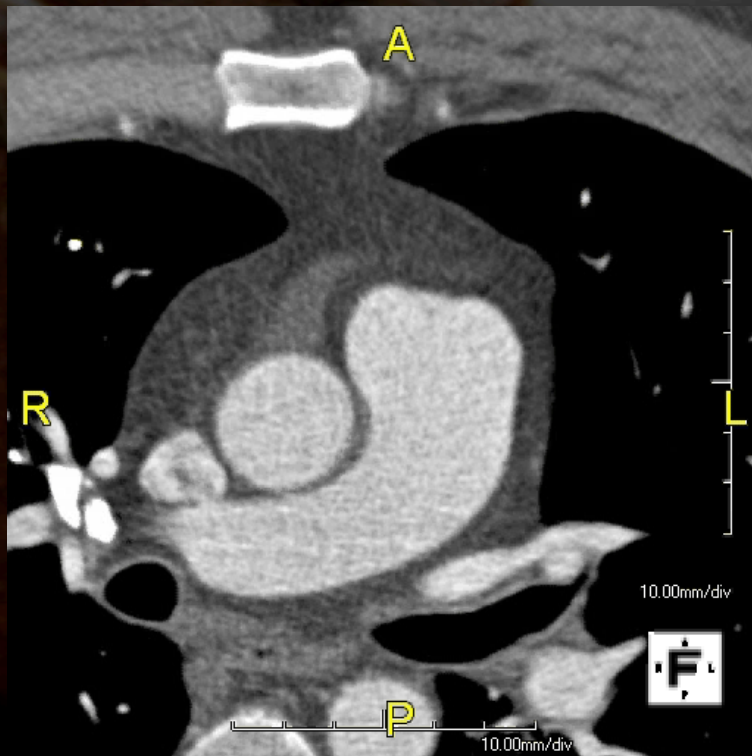
Length: 3.16mm
Mean: 282.91
Max: 351
Min: 145
SDev: 68.32

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10.00mm/div

Another Recent Case

- ◆ 43 year-old male, atypical CP
- ◆ Biomarkers neg, ECG: NSST changes



Conclusions

- ◆ **Coronary / Cardiac CTA is gaining acceptance in real world situations**
- ◆ **Radiologists can and should participate in cardiac imaging**
- ◆ **Although labor intensive, protocol-driven CCTA promotes uniformity and quality across many locations throughout the practice**
- ◆ **Interpretation of volumetric datasets should occur volumetrically**

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Conclusions

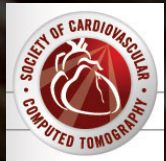
- ◆ **Thin-client (or no client) 3D software allows flexibility**
- ◆ **Timely communication of results is very important; sharing images helps too!**

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More Information:



North American Society for Cardiovascular Imaging <http://www.nasci.org>



Society of Cardiovascular Computed Tomography <http://www.scct.org>



ACR Certificate of Added Proficiency (CoAP) in Cardiac CT

<http://www.acr.org/secondarymainmenucategories/acr-education/coap.aspx>

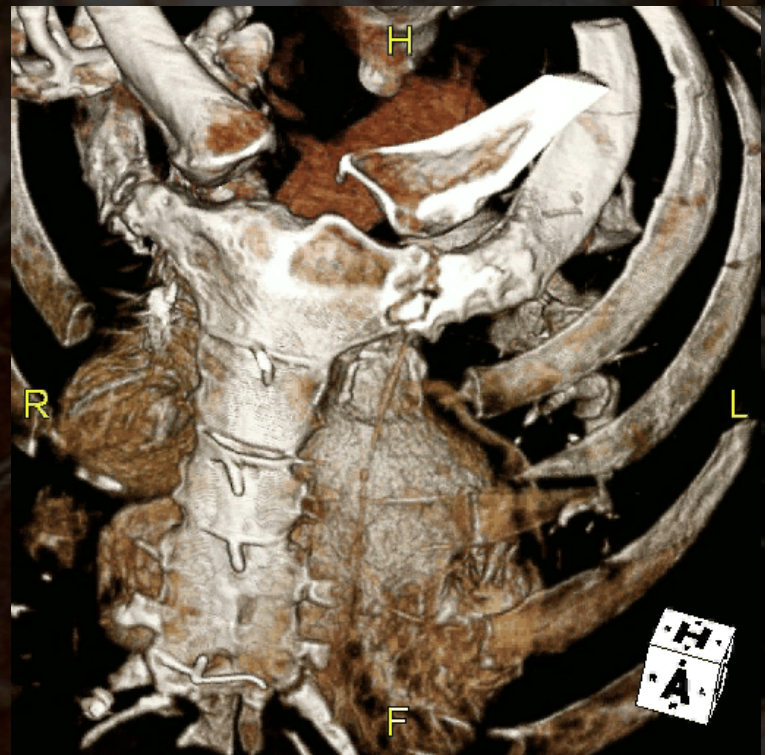
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Thanks for your attention!!

◆Special Thanks to:

- ◆Phil Araoz, MD
- ◆Eric Williamson, MD
- ◆Dominik Fleischmann, MD
- ◆Geoff Rubin, MD
- ◆Marty Beuning, CIO, NWR





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