Coronary / Cardiac CT in Private Practice

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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

<table>
<thead>
<tr>
<th>Medication</th>
<th>β Blockers (β1 selective Blocker)</th>
<th>CA Channel Blocker</th>
<th>Nitroglycerin</th>
</tr>
</thead>
<tbody>
<tr>
<td>i.e. Atenolol, Metoprolol</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>i.e. Verapamil, Diltiazem</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heart</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sick sinus syndrome</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Severe bradycardia</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>2nd / 3rd degree heart block</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Hypotension (systolic BP &lt; 100 mm Hg)</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Severe aortic stenosis</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Early myocardial infarction</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Obstructive cardiomyopathy</td>
<td>0</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Constrictive pericarditis</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>High doses of other agents depressing</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>SA and AV nodes (digoxin, anti-arrhythmica)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lung</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma</td>
<td>++</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bronchospams</td>
<td>++</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Severe COPD</td>
<td>++</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe anemia</td>
<td>0</td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>Increased intracranial pressure</td>
<td>0</td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>Migraine sensitive to nitrates</td>
<td></td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>Peripheral arterial occlusive disease</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hypersensitivity</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

| 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
# CECTA Study Workflow

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Decrease HR and R-to-R variability</th>
<th>Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal</strong></td>
<td>Steady heart rate of 50-65 beats per minute (bpm)</td>
<td></td>
</tr>
<tr>
<td>A Questionnaire</td>
<td>rule out contraindications</td>
<td></td>
</tr>
<tr>
<td>Obtain baseline HR &amp; BP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>if HR ≤ 65 bpm</td>
<td>[D]</td>
<td></td>
</tr>
<tr>
<td>if HR &gt; 65 bpm</td>
<td>[B]</td>
<td></td>
</tr>
<tr>
<td>Oral Atenolol (Tenormin®)</td>
<td>100 mg p.o. 1-2 hour before cardiac CT</td>
<td></td>
</tr>
<tr>
<td>if HR ≤ 65 bpm</td>
<td>[D]</td>
<td></td>
</tr>
<tr>
<td>if HR &gt; 65 bpm</td>
<td>[C]</td>
<td></td>
</tr>
<tr>
<td>Intravenous Metoprolol (Lopressor®) injection with patient on the scanner table</td>
<td>5 mg i.v. slow injection over 1 min</td>
<td></td>
</tr>
<tr>
<td>wait 3-4 min</td>
<td>if HR ≤ 65 bpm  -- [D]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>if HR &gt; 65 bpm  -- repeat [C] up to two times at 3-4 min interval</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maximal dosis: 15 mg Metoprolol (Lopressor®)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>if HR ≤ 65 bpm  -- [D]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>if HR &gt; 65 bpm  -- [D] regardless of HR</td>
<td></td>
</tr>
<tr>
<td>Purpose</td>
<td>coronary artery dilatation for better visualization</td>
<td></td>
</tr>
<tr>
<td>Questionnaire</td>
<td>rule out contraindications</td>
<td></td>
</tr>
<tr>
<td><strong>Sublingual nitroglycerin (NitroQuick®)</strong></td>
<td>0.4 mg tablet</td>
<td></td>
</tr>
<tr>
<td>wait 5 min</td>
<td>[E]</td>
<td></td>
</tr>
<tr>
<td>Scan</td>
<td>[F]</td>
<td></td>
</tr>
<tr>
<td>Post scan monitoring</td>
<td>outpatients: for 30 min</td>
<td></td>
</tr>
<tr>
<td>HR &amp; BP</td>
<td>inpatients: on ward</td>
<td></td>
</tr>
<tr>
<td>Recommendations</td>
<td>outpatients: 3h not operate machinery, i.e. driving car</td>
<td></td>
</tr>
</tbody>
</table>

**CA Channel Blockers**

- Oral Diltiazem (Cardizem®, regular release): 30 mg p.o. or doubling oral dose for patients currently taking oral calcium channel blockers
  
  OR

- Intravenous Diltiazem (Cardizem Monovial ®): 10 mg i.v. over 2 min repeat 10 mg i.v. in every 10 min to maximal dose of 40 mg
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
Appropriateness for CCTA: New Guidelines 2010


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

## 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)

### 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)

7. • ECG uninterpretable
   • Low pretest probability of CAD
   A (7)

8. • Nondiagnostic ECG or equivocal cardiac biomarkers
   • Low pretest probability of CAD
   A (7)
### Detection of CAD in Other Clinical Scenarios—New-Onset or Newly Diagnosed Clinical HF and No Prior CAD

| 13. | Reduced left ventricular ejection fraction | A (7) |
|     | Low pretest probability of CAD             |      |

| 13. | Reduced left ventricular ejection fraction | A (7) |
|     | Intermediate pretest probability of CAD    |      |

### Detection of CAD in Other Clinical Scenarios—Preoperative Coronary Assessment Prior to Noncoronary Cardiac Surgery

| 15. | Coronary evaluation before noncoronary cardiac surgery | A (7) |
|     | Intermediate pretest probability of CAD           |      |

### Use of CTA in the Setting of Prior Test Results—Prior ECG Exercise Testing

| 20. | Normal ECG exercise test | A (7) |
|     | Continued symptoms      |      |

| 21. | Prior ECG exercise testing | A (7) |
|     | Duke Treadmill Score—intermediate risk findings |      |

### 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) |
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%

Halpern, AJR 2010, 194 (5) pp. 1257-62
Detection of CAD in other scenarios

<table>
<thead>
<tr>
<th>Use of CTA in the Setting of Prior Test Results — Evaluation of New or Worsening Symptoms in the Setting of Past Stress Imaging Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>29. Previous stress imaging study normal</td>
</tr>
</tbody>
</table>

Risk Assessment Postrevascularization (PCI or CABG) — Symptomatic (Ischemic Equivalent)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>39. Evaluation of graft patency after CABG</td>
</tr>
</tbody>
</table>

Risk Assessment Postrevascularization (PCI or CABG) — Asymptomatic — Prior Coronary Stenting

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>43. Prior left main coronary stent with stent diameter ≥3 mm</td>
</tr>
</tbody>
</table>

### Cardiac Structure and Function

**Evaluation of Cardiac Structure and Function — Adult Congenital Heart Disease**

- Assessment of anomalies of coronary arterial and other thoracic arteriovenous vessels
  - A (9)
- Assessment of complex adult congenital heart disease
  - A (8)

**Evaluation of Cardiac Structure and Function — Evaluation of Ventricular Morphology and Systolic Function**

- Evaluation of left ventricular function
  - Following acute MI or in HF patients
  - Inadequate images from other noninvasive methods
  - A (7)
- Quantitative evaluation of right ventricular function
  - A (7)
- Assessment of right ventricular morphology
  - Suspected arrhythmogenic right ventricular dysplasia
  - A (7)

**Evaluation of Cardiac Structure and Function — Evaluation of Intra- and Extracardiac Structures**

- Characterization of native cardiac valves
  - Suspected clinically significant valvular dysfunction
  - Inadequate images from other noninvasive methods
  - A (8)
- Characterization of prosthetic cardiac valves
  - Suspected clinically significant valvular dysfunction
  - Inadequate images from other noninvasive methods
  - A (8)
- Evaluation of cardiac mass (suspected tumor or thrombus)
  - Inadequate images from other noninvasive methods
  - A (8)
- Evaluation of pericardial anatomy
  - A (8)
- Evaluation of pulmonary vein anatomy
  - Prior to radiofrequency ablation for atrial fibrillation
  - A (8)
- Noninvasive coronary vein mapping
  - Prior to placement of biventricular pacemaker
  - A (8)
- 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

  - 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;561397-406
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
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

Trends in CCTA: 2006-2008

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 disease (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

Rev. 2011
CIGNA: ICD9 (Diagnosis) Codes

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

† 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 Angstons 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.

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
“Turf” in CVI

✦ Every situation is different
✦ Training requirements
✦ Call responsibilities
✦ Monetary issues
✦ 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
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
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)

<table>
<thead>
<tr>
<th>CLINICAL SCENARIO</th>
<th>FOR THESE INDICATIONS:</th>
<th>ORDER THIS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYMPTOMATIC, NONACUTE SX (? Ischemic Eq.) NO KNOWN Heart Disease</td>
<td>• LOW Pre-test Probability: ECG uninterpretable OR unable to exercise</td>
<td>CCTA</td>
</tr>
<tr>
<td></td>
<td>• INTERMEDIATE Pre-Test Probability (+/- ECG interpretable, can exercise)</td>
<td></td>
</tr>
<tr>
<td>SYMPTOMATIC, ACUTE SX (Urgent Presentation) NO KNOWN Heart Disease</td>
<td>LOW OR INTERMEDIATE:</td>
<td>CCTA</td>
</tr>
<tr>
<td></td>
<td>• Normal ECG and biomarkers OR ECG uninterpretable OR ECG / biomarkers non-diagnostic</td>
<td></td>
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<tr>
<td>PRIOR TEST RESULTS</td>
<td>• NORMAL STRESS ECG TEST WITH CONTINUED SX; DUKE TREADMILL SCORE INTERMEDIATE RISK</td>
<td>CCTA</td>
</tr>
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<td></td>
<td>• NEW/WORSENING SX, PREVIOUS NORMAL STRESS IMAGING STUDY</td>
<td></td>
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<tr>
<td></td>
<td>• DISCORDANT OR EQUIVOCAL STRESS ECG AND IMAGING RESULTS</td>
<td></td>
</tr>
<tr>
<td>SYMPTOMATIC</td>
<td>Evaluate suspected CORONARY ANOMALIES</td>
<td>CCTA</td>
</tr>
<tr>
<td>NEW DX OR ONSET HEART FAILURE (NO PRIOR CAD)</td>
<td>LOW OR INTERMEDIATE RISK patients with reduced EF</td>
<td>CCTA</td>
</tr>
<tr>
<td>CARDIAC MASS / THROMBUS / VALVULAR DISEASES / PERICARDIAL EVAL. CONGENITAL HEART DISEASE</td>
<td>• If limited info from Echo, TEE, or MRI (problem solving)</td>
<td>Cardiac CT</td>
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<tr>
<td></td>
<td>• STRUCTURE AND FUNCTION</td>
<td></td>
</tr>
<tr>
<td>RISK ASSESSMENT POST PCI OR CABG</td>
<td>• SYMPTOMATIC (ISCHEMIC EQUIVALENT) : EVALUATE GRAFT PATENCY</td>
<td>CTA CHEST- BYPASS GRAFT</td>
</tr>
<tr>
<td></td>
<td>• Prior to Re-Do CABG (assess positions and patency of bypass grafts- esp. LIMA)</td>
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<td></td>
<td>ASYMPTOMATIC, PRIOR LEFT MAIN STENT (&gt; 3mm)</td>
<td>CCTA</td>
</tr>
<tr>
<td>CORONARY CALCIUM SCORE</td>
<td>• INTERMEDIATE 10-YEAR RISK FOR CHD EVENTS (FRS = 10-20%)</td>
<td>CAC SCORE</td>
</tr>
<tr>
<td></td>
<td>• LOW 10-YEAR RISK BUT FAMILY HISTORY OF PREMATURE CHD</td>
<td></td>
</tr>
<tr>
<td>CONTRAINDICATIONS to CORONARY CTA: (MOST ARE RELATIVE)</td>
<td>• Weight &gt;300 lbs</td>
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<td></td>
<td>• Calcium Score &gt;500</td>
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<td>• Iodine (Contrast) allergy (and not pre-medicated)</td>
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<td>• Contraindication to B-blocker, NTG</td>
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<td></td>
<td>• Severe Asthma or COPD</td>
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<td>• AFIB</td>
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</table>

**FRAMINGHAM RISK CALCULATOR:** [http://www.mdcalc.com/framingham-cardiac-risk-score](http://www.mdcalc.com/framingham-cardiac-risk-score)

### From:
CCTA Reporting Form

Name: ______________________
MRN: ______________________

Northwest Radiology Network
Coronary CTA Preliminary Interpretation

Study Date __/__/____
mo day year

FACILITY: ______________________

RADIOLOGIST: ______________________

TIME OF WET READ: ______________________

CALCUM SCORE: ______________________

OTHER FINDINGS:

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<td>RAMUS (17)</td>
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<td></td>
<td>Other (17)</td>
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</table>

Diagram of coronary blood vessels.
# Cardiac CT Order Form

**Patient Name:**

**DOB:**

**Sex:**

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
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<tbody>
<tr>
<td>☐ 75672 - CCTA</td>
<td>Cardiac Structure and Venous</td>
</tr>
<tr>
<td>☐ 75674 - CTA of the Coronary Arteries</td>
<td></td>
</tr>
<tr>
<td>☐ 75676 - CTA of the Coronary Arteries and Veins</td>
<td></td>
</tr>
<tr>
<td>☐ 75873 - CTA - Structure / Morphology of Congenital Heart</td>
<td></td>
</tr>
</tbody>
</table>

**Diagnoses:**

- CTA with Morphology
- CTA of Coronary Arteries
- CTA Coronary Arteries + Veins
- CTA of Congenital Heart

- 411.1 Angina (unstable, pre-infarction, progressive)
- 412 Old Myocardial Infarct
- 413.0 Angina Decubitus
- 413.1 Pericardial 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
- 414.6 Ischemic Cardiomyopathy
- 424.1 Aortic Valve Disorders
- 788.05 Shortness of Breath
- 788.50 Unspec Chest Pain
- 788.51 Precedital Pain
- 788.59 Other Chest Pain
- 789.30 Unspec Abnormal Function Study of CV System
- 790.31 Abnormal ECG
- 792.81 Pre-Op CVD Exam
- 794.11 All Other Abnormal ECGs
- 794.31 Abnormal ECGs
- 794.81 Other Abnormalities

**Other:**

**Miscellaneous:**

- 75571 Calcium Score ONLY

---

**PLEASE FAX INSURANCE CARDS WITH ORDER! THANK YOU.**
# Cardiac CT Patient Prep Form

## Patient Preparation/Info

**ORDERING PHYSICIAN SIGNATURE:**

---

**Test Date:**

---

**Time:**

---

**Please fax the following information to:**

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

&bull; Dosage of Beta Blockers

&bull; Heart Rate

&bull; Blood Pressure

&bull; BUN

&bull; Blood or (less than one month old)

#### APPROPRIATE INDICATIONS

- **Chest Pain Syndrome** -
  1. Intermediate pre-test probability + abnormal ECG OR unable to exercise
  2. Patient with equivocal stress test
  3. Evaluation of suspected coronary anomalies

- **Heart Failure** - New onset heart failure, assess ejection fraction.

- **Electrophysiology** -
  1. Pulmonary vein isolation prior to ablation for atrial fibrillation
  2. 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

1. **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.

2. No caffeine, tobacco or alcohol for 24 hours prior to test.
3. No erectile dysfunction (Viagra, Cialis, etc.) medications for 48 hours prior to test.
4. Instruct patient to drink 3 – 5 glasses of water prior to the test.
5. 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

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

---

**Referring Physician:**

---

**Fax number for results:**

---

*CTA 10/2008 PLEASE FAX INSURANCE CARDS WITH ORDER! THANK YOU.*
Cardiac CT Acquisition / Reconstruction Issues
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
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 (Meadrad 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
Cardiac CT Workflow
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
CCTA Workflow Problems

✦ LARGE number of images
✦ Studies done at many locations
✦ Time constraints to interpretation
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
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
Interpretation Strategies
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
"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
**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

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

**Storage**
- Virtual Servers = IBM DS3524
- Virtual Desktops = NetApp FAS2040
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
CCTA Reporting Form

Northwest Radiology Network
Coronary CTA Preliminary Interpretation

Name: ______________________
MRN: ______________________

Study Date  __/ __/ _____
mo day year

FACILITY: ______________________

RADIOLOGIST: ______________________

TIME OF WET READ: __________

CALCIUM SCORE: __________

OTHER FINDINGS:

FINDINGS

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<td>Other ______</td>
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</table>
A Recent Case Study

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

Interactive MPR
Minimal lumen = 1 mm
Normal segment = 3.2 mm
~ 65% diameter reduction
Another Recent Case

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

✦ Thin-client (or no client) 3D software allows flexibility

✦ Timely communication of results is very important; sharing images helps too!
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/secondarymainmenumenucategories/acr-education/coap.aspx]
Thanks for your attention!!

✧ Special Thanks to:
✧ Phil Araoz, MD
✧ Eric Williamson, MD
✧ Dominik Fleischmann, MD
✧ Geoff Rubin, MD
✧ Marty Beuning, CIO, NWR

xraydoc97@yahoo.com