INTRODUCTION

- Coronary computed tomographic angiography (CCTA) is a noninvasive imaging study that uses intravenously administered contrast material and high-resolution, rapid imaging computed tomography (CT) equipment to obtain detailed volumetric images of the coronary blood vessels (while cardiac CT perfusion imaging is sometimes added to CCTA, the current utility of CT perfusion imaging is low and appears to require further study) (Gerber & Manning 2018).

- CCTA remains controversial for the assessment of asymptomatic high risk individuals, and while endorsed by some literature (Taylor 2010), it is not clearly recommended by most others (Mark 2010; Gerber & Manning 2018; Douglas 2018; Wolk 2013; Greenland 2010).

- Image quality depends on keeping HR < 70, a regular rhythm, limited calcification and stents, ≥ 5 second breath hold, and vessels requiring imaging ≥ 1.5 mm diameter (Gerber & Manning 2018).

- Coronary artery disease (CAD) stenosis ≥ 50% is considered clinically significant or obstructive CAD. CAD and ischemic heart disease (IHD) mean the same thing. Hemodynamically or functionally significant CAD means the degree of stenosis is severe enough to cause ischemia. This is discussed in more detail in the Additional Information section (Fihn 2012; Wolk 2013; Montalescot 2013; Gerber & Manning 2018; Tobis 2007).

- **Stable patients without known CAD** fall into 2 categories (Fihn 2012; Wolk 2013; Montalescot 2013):
  - **Asymptomatic**, for whom global risk of CAD events can be determined from coronary risk factors, using calculators available online (see Part III in the Additional Information section).
  - **Symptomatic**, for whom we estimate the pretest probability that their chest-related symptoms are due to clinically significant (≥ 50%) CAD
The Three Types of Chest Pain or Discomfort

- **Typical Angina (Definite)** is defined as including all 3 characteristics:
  1) Substernal chest pain or discomfort with characteristic quality and duration
  2) Provoked by exertion or emotional stress
  3) Relieved by rest and/or nitroglycerin

- **Atypical Angina (Probable)** has only 2 of the above characteristics

- **Nonanginal Chest Pain/Discomfort** has only 0-1 of the above characteristics

Once the type of chest pain has been established from the medical record, the Pretest Probability of significant CAD is estimated from the Diamond Forrester Table below, recognizing that additional coronary risk factors could increase pretest probability (Wolk 2013):

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Nonanginal Chest Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 39</td>
<td>Men</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40–49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>≥ 60</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

- **Very low**: < 5% pretest probability of CAD, usually not requiring stress evaluation (Fihn 2012)
- **Low**: 5-10% pretest probability of CAD
- **Intermediate**: 10% - 90% pretest probability of CAD
- **High**: > 90% pretest probability of CAD (Fihn 2012)

**Indications for CCTA**
(Gerber & Manning 2018; Fihn 2012; Montalescot 2013; Wolk 2010; Taylor 2010)

- **Evaluation in suspected CAD** (Douglas 2015; Newby 2015; Nicol 2008; Fordyce 2016; Moss 2017):
  - Intermediate pretest probability patients who are not suitable for stress echo (see Additional Information section)
  - Low pretest probability patients who are not suitable for either exercise stress ECG (uninterpretable) or stress echo (see Additional Information section)
- Appropriate exercise electrocardiogram (ECG) stress test with low Duke Score (≥ 5) and continued symptoms that are concerning for CAD, usually typical or atypical angina
- Appropriate exercise ECG stress test with intermediate (negative 10 to +4) Duke Score.
- Equivocal, borderline, discordant, or inconclusive prior stress imaging evaluation, including discordant exercise ECG and stress imaging
- Repeat non-invasive coronary testing in patient with new or worse symptoms since prior normal stress imaging (Wolk 2013; Taylor 2010)
- Newly diagnosed clinical systolic heart failure without known CAD or current CAD evaluation, in the presence of angina or an anginal equivalent (Patel 2012; Patel 2013; Wolk 2013; Taylor 2010)
- Reduced left ventricular ejection fraction (<40% EF), when invasive coronary arteriography is not the preferred method of evaluation
- An alternative to coronary angiography before valve surgery or transcatheter intervention in patients with severe valvular heart disease (VHD) and low or intermediate pretest probability of CAD or in whom conventional coronary angiography is technically not feasible or associated with a high risk (Baumgartner 2017; Nishimura 2014)
- Unable to undergo otherwise appropriate non-invasive coronary evaluation with any of the following: exercise ECG, myocardial perfusion imaging (MPI), and stress echocardiography (SE) (Douglas 2015; Newby 2015; Nicol 2008; Fordyce 2016)
- To establish the etiology of chronic secondary mitral regurgitation (Nishimura 2014)
- Evaluation of coronary anomaly or aneurysm (e.g. post Kawasaki’s disease) when CMR is not available (Datta 2005; Newburger 2016; Newburger 2018; Grani 2017)
- For evaluation of coronary artery bypass grafts, to assess (Eisenberg 2017):
  - Patency and location, when invasive coronary arteriography was unable to acquire adequate images
  - Patency, if it might avoid invasive coronary arteriography
  - Coronary bypass graft location when reoperative cardiac or other chest surgery requires

**ADDITIONAL INFORMATION**

**Unsuitability for Stress Echo**
(Askew 2018; Henzlova 2016)

I. Poor Quality Echo Image
   - Obesity with BMI over 40 or poor acoustic imaging window

II. Inability to Exercise
   - Physical infirmities precluding a reasonable ability to exercise for at least 3 full minutes of Bruce protocol
   - The patient has limited functional capacity (< 4 METS) such as one of the following:

3—CCTA 2019 Proprietary
i. Cannot take care of their activities of daily living (ADLs) or ambulate
ii. Cannot walk 2 blocks on level ground
iii. Cannot climb 1 flight of stairs
iv. Cannot vacuum, dust, do dishes, sweep, or carry a small grocery bag

• Patients who cannot walk up a single flight of stairs at even a slow pace or even perform ADLs based upon documented limitations

III. Comorbidity Related
• Prior cardiac surgery (coronary artery bypass graft or valvular), CHF with left ventricular ejection fraction ≤ 40%
• Severe chronic obstructive pulmonary disease (COPD) with pulmonary function test (PFT) documentation, severe shortness of breath on minimal exertion, or requirement of home oxygen during the day
• Poorly controlled hypertension, with systolic blood pressure (BP) > 180 or Diastolic BP > 120
• Medical instability or serious acute illness, where maximal exercise is not recommended or appropriate (e.g. acute myocarditis or pericarditis, active infective endocarditis, acute aortic dissection)
• Resting wall motion abnormalities that would make exercise stress echocardiography (SE) interpretation difficult, which includes left bundle branch block (LBBB)
• More than moderate valvular heart disease, when coronary data, not valvular hemodynamics, are required

IV. ECG Related Uninterpretable Wall Motion
• Pacemaker or implantable cardioverter defibrillator (ICD)
• Poorly controlled atrial fibrillation/ectopy
• Frequent premature ventricular contractions (PVCs)
• Ventricular pre-excitation (e.g. Wolff Parkinson White)
• Complete LBBB (SE doable, but more difficult to interpret)

V. Risk Related
• High pretest probability in suspected CAD
• Intermediate or high global risk in patients requiring type IC antiarrhythmic drugs
• Patients with prior coronary revascularization
• Arrhythmia risk with exercise and provocation of arrhythmia not required for test
• Left ventricular ejection fraction ≤ 40%
Unsuitability for MPI
(Henzlova 2016; Chareonthaitawee 2018)

- Patient cannot be adequately positioned or imaged with MPI due to comorbidity, body habitus
- Intolerance to required coronary vasodilators, pulmonary or allergic, either documented or anticipated.
- Uncontrolled hypertension, systolic > 200 or diastolic > 110
- Dipyridamole within < 48 hours
- Relative unsuitability due to:
  - Hypotension or marked bradyarrhythmia
  - Interfering medications: Theophylline/aminophylline, caffeine, or theobromine within the past 12-24 hours
  - Severe aortic stenosis
  - Seizure disorder with potential for adenosine provocation

Coronary Artery Calcium Scoring
(Gerber & Kramer 2018)

Non-contrast coronary computed tomography (non-contrast coronary CT) and its older technological version, electron beam computed tomography (EBCT), provide quantitative coronary artery calcium scoring, which is appropriate for further evaluation of coronary risk in asymptomatic patients without known cardiovascular disease, who are at low to intermediate or intermediate global risk for coronary or overall cardiovascular disease. Non-contrast coronary CT (computed tomography) and EBCT are supported by a separate CPT code and guideline document with references titled EBCT or Non-Contrast Coronary CT.

Definitions of Coronary Artery Disease
(Fihn 2012; Montalescot 2013; Patel 2017; Mintz 2016; Tobis 2007)

1. Percentage stenosis refers to the reduction in diameter stenosis when angiography is the method and refers to cross sectional narrowing when intravascular ultrasound (IVUS) is the method of determination.
2. Coronary artery calcification is a marker of risk, as measured by Agatston score on coronary artery calcium imaging. It is not a diagnostic tool so much as it is a risk stratification tool. Its incorporation into global risk can be achieved by using the MESA risk calculator.
3. Stenoses ≥ 50% are considered obstructive coronary artery disease (also referred to as clinically significant), while stenoses ≤ 50% are considered nonobstructive coronary artery disease (Gerber & Manning 2018).
4. Ischemia-producing disease (also called hemodynamically or functionally significant disease, for which revascularization might be appropriate) generally implies at least one of the following:
   i. Suggested by percentage diameter stenosis ≥ 70% by angiography; borderline lesions are 40-70% (Fihn 2012; Tobis 2007)
For a left main artery, suggested by a percentage stenosis ≥ 50% or minimum lumen cross sectional area on IVUS ≤ 6 square mm (Fihn 2012; Mintz 2016)

iii. FFR (fractional flow reserve) ≤ 0.80 for a major vessel (Mintz 2016)

iv. Demonstrable ischemic findings on stress testing (ECG or stress imaging), that are at least mild in degree

5. A major vessel would be a coronary vessel that would typically be substantial enough for revascularization, if it were indicated. Lesser forms of coronary artery disease would be labeled as “limited” and not major (i.e. a 50% lesion in a tiny septal or modest size mid PDA would be limited obstructive coronary artery disease).

6. Microvascular ischemic coronary artery disease, as might be described by a normal FFR (fractional flow reserve) above 0.80 with a reduced CFR (coronary flow reserve less than 2.5), has not otherwise been addressed in this manuscript, because it is very rarely an issue in compliance determinations. However, it would constitute a form of ischemic heart disease.

7. FFR is the distal to proximal pressure ratio across a coronary lesion during maximal hyperemia induced by either intravenous or intracoronary adenosine. Less than or equal to 0.80 is considered a significant reduction in coronary flow. Newer iterations such as iFR (instantaneous wave free ratio) might supersede basic FFR technology in the near future.

8. New technology is evolving that estimates FFR from CCTA images. This is covered under the separate NIA Guideline for FFR-CT.

**Anginal Equivalent**
(Moya 2009; Shen 2017; Fihn 2012)

Development of an anginal equivalent (e.g. shortness of breath, fatigue, or weakness) either with or without prior coronary revascularization should be based upon the documentation of reasons to suspect that symptoms other than chest discomfort are not due to other organ systems (e.g. dyspnea due to lung disease, fatigue due to anemia), by presentation of clinical data such as respiratory rate, oximetry, lung exam, etc. (as well as d-dimer, chest CT(A), and/or PFTs, when appropriate), and then incorporated into the evaluation of coronary artery disease as would chest discomfort. Syncope per se is not an anginal equivalent.
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACS</td>
<td>Acute coronary syndrome</td>
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<tr>
<td>CABG</td>
<td>Coronary artery bypass grafting surgery</td>
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<tr>
<td>CAD</td>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>CCS</td>
<td>Coronary calcium score</td>
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<tr>
<td>CCTA</td>
<td>Coronary computed tomography angiography</td>
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<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
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<tr>
<td>MI</td>
<td>Myocardial infarction</td>
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<tr>
<td>MPI</td>
<td>Myocardial Perfusion Imaging</td>
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<tr>
<td>PCI</td>
<td>Percutaneous coronary intervention</td>
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<tr>
<td>SE</td>
<td>Stress echocardiography</td>
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<tr>
<td>TTE</td>
<td>Transthoracic echocardiography</td>
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<tr>
<td>TAVR</td>
<td>Transcatheter aortic valve replacement</td>
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REFERENCES


Newburger JW, de Ferranti DSD, Fulton DR. Cardiovascular sequelae of Kawasaki disease: Clinical features and evaluation. UpToDate. Waltham, MA; April, 2018. Available at: https://www.uptodate.com/contents/cardiovascular-sequelae-of-kawasaki-disease-clinical-features-and-evaluation?search=Ischemia%20in%20Kawasaki&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H13231752 Retrieved May 24, 2018


Taylor AJ, Cerqueira MC, Hodgson JM, et al. 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 Appropriateness 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. JACC. 2010;56(22):1864-1894.


