ACCF/SCCT/ACR/AHA/ASE/ASNC/SCAI/SCMR 2010 Appropriate Use Criteria for Cardiac Computed Tomography

American College of Cardiology Foundation Appropriate Use Criteria Task Force, Society of Cardiovascular Computed Tomography, American College of Radiology, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Society for Cardiovascular Angiography and Interventions, Society for Cardiovascular Magnetic Resonance, Allen J. Taylor, Manuel Cerqueira, John McB. Hodgson, Daniel Mark, James Min, Patrick O'Gara, and Geoffrey D. Rubin

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APPROPRIATE USE CRITERIA

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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 Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance

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Abstract

The American College of Cardiology Foundation (ACCF), along with key specialty and subspecialty societies, conducted an appropriate use review of common clinical scenarios where cardiac computed tomography (CCT) is frequently considered. The present document is an update to the original CCT/cardiac magnetic resonance (CMR) appropriateness criteria published in 2006, written to reflect changes in test utilization, to incorporate new clinical data, and to clarify CCT use where omissions or lack of clarity existed in the original criteria (1).

The indications for this review were drawn from common applications or anticipated uses, as well as from current clinical practice guidelines. Ninety-three clinical scenarios were developed by a writing group and scored by a separate technical panel on a scale of 1 to 9 to designate appropriate use, inappropriate use, or uncertain use.

In general, use of CCT angiography for diagnosis and risk assessment in patients with low or intermediate risk or pretest probability for coronary artery disease (CAD) was

viewed favorably, whereas testing in high-risk patients, routine repeat testing, and general screening in certain clinical scenarios were viewed less favorably. Use of noncontrast computed tomography (CT) for calcium scoring was rated as appropriate within intermediate- and selected low-risk patients. Appropriate applications of CCT are also within the category of cardiac structural and functional evaluation. It is anticipated that these results will have an impact on physician decision making, performance, and reimbursement policy, and that they will help guide future research.

Preface

In an effort to respond to the need for the rational use of imaging services in the delivery of high-quality care, the ACCF has undertaken a process to determine the appropriate use of cardiovascular imaging for selected patient indications.

Appropriate use criteria publications reflect an ongoing effort by the ACCF to critically and systematically create, review, and categorize clinical situations where diagnostic tests and procedures are utilized by physicians caring for patients with cardiovascular diseases. The process is based on current understanding of the technical capabilities of the imaging modalities examined. Although not intended to be entirely comprehensive, the indications are meant to identify common scenarios encompassing the majority of contemporary practice. Given the breadth of information they convey, the indications do not directly correspond to the ninth revision of the *International Classification of Diseases* (ICD-9) system as these codes do not include clinical information, such as symptom status.

The ACCF believes that careful blending of a broad range of clinical experiences and available evidence-based information will help guide a more efficient and equitable allocation of healthcare resources in cardiovascular imaging. The ultimate objective of appropriate use criteria is to improve patient care and health outcomes in a cost-effective manner but is not intended to ignore ambiguity and nuance intrinsic to clinical decision making. Local parameters, such as the availability or quality of equipment or personnel, may influence the selection of appropriate imaging procedures. Appropriate use criteria thus should not be considered substitutes for sound clinical judgment and practice experience.

The ACCF appropriate use criteria process itself is also evolving. In the current iteration, technical panel members were asked to rate indications for CCT in a manner independent and irrespective of the prior published ACCF ratings for CCT and CMR (1) as well as the prior ACCF ratings for similar diagnostic stress imaging modalities such as cardiac radionuclide imaging (2) or stress echocardiography (3) (see Appendix A for the definitions of terms used throughout the indication set). Given the iterative nature of the process, readers are counseled not to compare too closely individual appropriate use ratings among modalities rated at different times over the past 2 years. A comparative evaluation of the appropriate use of multiple imaging techniques is currently being undertaken to assess the relative strengths of each modality for various clinical scenarios.

We are grateful to the technical panel, a professional group with a wide range of skills and insights, for their thoughtful and thorough deliberation of the merits of CCT for various indications. In addition to our thanks to the technical panel for their dedicated work and review, we would like to offer special thanks to the many individuals who provided a careful review of the draft indications; to Peggy Christiansen, the ACCF librarian for her comprehensive literature searches; to Lindsey Law, Starr Webb, and Joseph M. Allen, who continually drove the process forward; and to Allen J. Taylor, MD, the chair of the writing committee for his dedication, insight, and leadership.

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1. Introduction

This report addresses the appropriate use of CCT. Improvements in cardiovascular imaging technology and their application, coupled with increasing therapeutic options for cardiovascular disease, have led to an increase in cardiovascular imaging. At the same time, the armamentarium of noninvasive diagnostic tools has expanded with innovations in new contrast agents, molecular radionuclide imaging, perfusion echocardiography, computed tomography for coronary angiography and calcium scoring, and magnetic resonance imaging for myocardial structure and viability. As the field of CCT continues to advance along with other imaging modalities, the healthcare community needs to understand how to best incorporate this technology into daily clinical care.

All prior appropriate use criteria publications from the ACCF and collaborating organizations have reflected an ongoing effort to critically and systematically create, review, and categorize the appropriate use of certain cardiovascular diagnostic tests. The ACCF recognizes the importance of revising these criteria in a timely manner in order to provide the cardiovascular community with the most accurate indications. The present document is the second update to an existing appropriate use criteria document, the "ACCF/ACR/SCCT/SCMR/ASNC/SCAI/SIR Appropriateness Criteria for Cardiac Computed Tomography and Cardiac Magnetic Resonance Imaging," published in 2006 (1). Clinicians, payers, and patients are interested in the specific benefits of CCT. Of importance, inappropriate use of CCT may be potentially harmful to patients and generate unwarranted costs to the health care system, whereas appropriate procedures should likely improve patients' clinical outcomes.

This is a critical shift because the intent is for the potential benefits and risks of the treatment to be explicitly considered, rather than the potential usefulness of a diagnostic test as a prelude to further treatment. This document presents the results of this effort, but it is critical to understand the background and scope of this document before interpreting the rating tables.

2. Methods

The indications included in this review are purposefully broad, and they comprise a wide array of cardiovascular signs and symptoms as well as clinical judgment as to the likelihood of cardiovascular findings.

Further description of the methods used for ranking of the selected clinical indications is outlined in Appendix B and is also found more generally in a previous publication, "ACCF Proposed Method for Evaluating the Appropriateness of Cardiovascular Imaging" (4). Briefly, this process combines evidence-based medicine and practice experience by engaging a technical panel in a modified Delphi exercise. Because the original CCT/CMR criteria document and methods paper was published, several important processes have been put in place to further enhance this process. They include convening a formal writing committee with diverse expertise in imaging, circulating the indications for external review prior to rating by the technical panel, ensuring appropriate balance of the technical panel, a standardized rating package, and creating formal roles for facilitating panel interaction at the face-to-face meeting.

The panel first rated indications independently. In rating these criteria, the Cardiac Computed Tomography Appropriate Use Criteria Technical Panel was asked to assess whether the use of the test for each indication is appropriate, uncertain, or inappropriate as defined in the following text.

An appropriate imaging study is one in which the expected incremental information, combined with clinical judgment, exceeds the expected negative consequences* by a sufficiently wide margin for a specific indication that the procedure is generally considered acceptable care and a reasonable approach for the indication.

The technical panel scores each indication as follows:

Score 7 to 9

Appropriate test for specific indication (test **is** generally acceptable and **is** a reasonable approach for the indication).

Score 4 to 6

Uncertain for specific indication (test **may** be generally acceptable and **may** be a reasonable approach for the indication). (Uncertainty also implies that more research and/or patient information is needed to classify the indication definitively.)

Score 1 to 3

Inappropriate test for specific indication (test **is not** generally acceptable and **is not** a reasonable approach for the indication).

Then the panel was convened for a face-to-face meeting for discussion of each indication. At this meeting, panel members were provided with their scores and a blinded summary of their peers' scores. After the consensus meeting, panel members were then asked to independently provide their final scores for each indication. Following the second round ratings, a supplemental rating process was conducted for a revised set of criteria for preoperative testing (31 to 38) and the clinical scenario of prior revascularization (40 to 41). Although these categories had been considered within the original 2 rounds of rating, the clinical scenarios were rewritten to more closely mirror prior documents, and the balloting was repeated.

The contributors acknowledge that the division of these scores into 3 categories of appropriate use is somewhat arbitrary and that the numeric designations should be viewed as a continuum. The contributors also recognize diversity in clinical opinion for particular clinical scenarios. Scores in the intermediate level of appropriate use should therefore be labeled uncertain, as critical patient or research data may be lacking or discordant. This designation should be a prompt to the field to carry out definitive research, whenever possible. It is anticipated that the appropriate use criteria reports will require updates as further data are generated and information from the implementation of the criteria is accumulated.

To avoid bias in the scoring process, the technical panel deliberately was not comprised solely of specialists in the particular procedure under evaluation. Specialists, while offering important clinical and technical insights, might have a natural tendency to rate the indications within their specialty as more appropriate than nonspecialists. In addition, care was taken in providing objective, nonbiased information, including guidelines and key references, to the technical panel. Panel members were not provided explicit cost information to help determine their appropriate use ratings, but they were asked to implicitly consider cost as an additional factor in their evaluation of appropriate use.

The level of agreement among panel members, as defined by RAND (5), was analyzed for each indication based on the BIOMED rule for a panel of 14 to 16 (a simplified RAND method for determining disagreement). Per the BIOMED definition, *agreement* was defined as an indication where 4 or fewer panel members ratings fell outside the 3-point region containing the median score. *Disagreement* was defined as a situation where at least 5 panel members ratings fell in both the appropriate and the inappropriate categories. Because the panel had 17 representatives, which exceeded the 16 addressed in this rule, an additional level of

*Negative consequences include the risks of the procedure (radiation or contrast exposure) and the downstream impact of poor test performance such as delay in diagnosis (false negatives) or inappropriate diagnosis (false positives).

agreement analysis as described by RAND was performed that examines the interpercentile range (IPR) compared with the interpercentile range adjusted for symmetry (IPRAS). This information was used by the moderator to guide the panel's discussion by highlighting areas of differences among the panel members. There was also a third category for indications that were not classified in either the agreement or disagreement categories. Any indication having disagreement was categorized as uncertain regardless of the final median score. Indications that met neither definition for agreement or disagreement are in a third, unlabeled, category.

3. General Assumptions

All indications were considered with the following important assumptions for CCT:

1. CCT is performed in accordance with best practice standards as delineated in the imaging guidelines of the Society of Cardiovascular Computed Tomography (6,7), by competent (8) and appropriately credentialed physicians. This includes the optimization of the scan protocol to limit radiation exposure.
2. CCT imaging equipment is available that has the minimal technical capabilities required for the indication. Typical technical parameters for studies performed on multi-detector row scanners include CT equipment enabling 64 or more slices, submillimeter spatial resolution, and gantry rotation time no greater than 420 milliseconds. Appropriate computer software must be available for image analysis.
3. Patients are optimally suited for CCT under the following conditions:
   a. Regular heart rate and rhythm including a heart rate at a level commensurate with the temporal resolution of the available scanner.
   b. Body mass index below 40 kg/m^2.
   c. Normal renal function.
4. For CT angiography, patient requirements may include the ability to:
   a. Hold still and follow breathing instructions.
   b. Tolerate beta blockers.
   c. Tolerate sublingual nitroglycerin.
   d. Lift both arms above the shoulders.
5. All indications for CCT were considered with the following important assumptions:
   a. All indications should first be evaluated based on the available medical literature.
   b. In many cases, studies published in the medical literature are reflections of the capabilities and limitations of the test but provide minimal information about the role of the test in clinical decision making.
   c. Appropriate use criteria development requires determination of a reasonable course of action for clinical decision making based on a risk/benefit trade-off as determined by individual patient indications.
6. For all stress imaging referenced in the indications, the mode of stress testing was assumed to be exercise for patients able to exercise. For patients unable to exercise, pharmacological stress testing was assumed to be used. Further background on the rationale for the assumption of exercise testing is available in the ACC/AHA 2002 Guideline Update for Exercise Testing (9).

4. Definitions

A complete set of definitions of terms used throughout the indication set is listed in Appendix A. These definitions were provided and discussed with the technical panel prior to ratings of indications.

Ischemic Equivalent Chest Pain Syndrome, Anginal Equivalent, or Ischemic Electrocardiographic Abnormalities: Any constellation of clinical findings that is clinically judged to be consistent with obstructive CAD. Examples of such findings include, but are not limited to, chest pain, chest tightness, burning, shoulder pain, jaw pain, and new electrocardiographic abnormalities suggestive of ischemic heart disease. Nonchest pain symptoms, such as dyspnea or worsening effort tolerance that are felt to be consistent with CAD may also be considered to be an anginal equivalent.

Determining Pretest Risk Assessment for Risk Stratification

Coronary Heart Disease (CHD) Risk in Asymptomatic Patients: Estimation of CHD risk applied to asymptomatic patients without known CHD. It is assumed that clinicians will use CCT studies in addition to standard methods of risk assessment as presented in the National Heart, Lung, and Blood Institute report (10) on "Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III [ATP III])."

Absolute risk is defined as the probability of developing CHD, including myocardial infarction or CHD death over a given time period. The ATP III report specifies absolute risk for CHD over the next 10 years. CHD risk refers to 10-year risk for any hard cardiac event. However, in acknowledgment that global absolute risk scores may be miscalibrated to certain populations (e.g., women, younger men), clinical judgment must be applied in selecting categorical risk thresholds.

- **CHD Risk—Low**
  Defined by the age-specific risk level that is below average. In general, low risk will correlate with a 10-year absolute CHD risk <10%.
- **CHD Risk—Intermediate**
  Defined by the age-specific risk level that is average or above average. In general, moderate risk will correlate

Table A. Pretest Probability of CAD by Age, Sex, and Symptoms

Age	Sex	Typical/Definite Angina Pectoris	Atypical/Probable Angina Pectoris	Nonanginal Chest Pain	Asymptomatic
<39	Men	Intermediate	Intermediate	Low	Very low
	Women	Intermediate	Very low	Very low	Very low
40–49	Men	High	Intermediate	Intermediate	Low
	Women	Intermediate	Low	Very low	Very low
50–59	Men	High	Intermediate	Intermediate	Low
	Women	Intermediate	Intermediate	Low	Very low
>60	Men	High	Intermediate	Intermediate	Low
	Women	High	Intermediate	Intermediate	Low

High: >90% pretest probability; intermediate: between 10% and 90% pretest probability; low: between 5% and 10% pretest probability; and very low: <5% pretest probability.
Modified from Gibbons et al. (9) to reflect all age ranges.

with a 10-year absolute CHD risk between 10% to 20%. Among women and younger men, an expanded intermediate risk range of 6% to 20% may be appropriate.

- **CHD Risk—High**
  Defined as the presence of diabetes mellitus in a patient ≥40 years of age, peripheral arterial disease or other coronary risk equivalents, or the 10-year absolute CHD risk of >20%.

Pretest Probability of Obstructive/Significant CAD for Symptomatic (Ischemic Equivalent) Patients: Once the physician determines the presence of symptoms that may represent obstructive CAD (ischemic equivalent present), the pretest probability of CAD should be assessed. There are a number of risk algorithms (11,12) available that can be used to calculate this probability. Clinicians should become familiar with those that pertain to the populations they encounter most often. In scoring the indications, the following probabilities as calculated from any of the various available algorithms should be applied:

- **Low pretest probability:** <10% pretest probability of CAD.
- **Intermediate pretest probability:** Between 10% and 90% pretest probability of CAD.
- **High pretest probability:** >90% pretest probability of CAD.

The method recommended by the ACC/AHA Guidelines for Chronic Stable Angina (13) is provided in the following text as 1 example of a method used to calculate pretest probability and is a modification of a previously published literature review (14). Please refer to definitions of angina and Table A. Please note that the table only predicts pretest probability in patients based upon presenting symptoms, age, and sex. Additional history and electrocardiographic evidence of prior infarction dramatically affect pretest probability. Although they are not incorporated into the algorithm, cardiovascular risk factors, discussed in risk assessment indications, may also affect pretest likelihood of CAD. Detailed normograms are available that incorporate the effects of a history of prior infarction, electrocardiographic Q waves, electrocardiographic ST- and T-wave changes, diabetes, smoking, and hypercholesterolemia (9).

5. Abbreviations

ACS = acute coronary syndrome
CABG = coronary artery bypass grafting surgery
CAD = coronary artery disease
CCS = coronary calcium score
CHD = coronary heart disease
CT = computed tomography
CTA = computed tomographic angiography
ECG = electrocardiogram
HF = heart failure
MET = estimated metabolic equivalent of exercise
MI = myocardial infarction
PCI = percutaneous coronary intervention

6. Results of Ratings

The final ratings for CCT (Tables 1 to 7) are listed by indication sequentially as obtained from second round rating sheets submitted by each panel member. The final score reflects the median score of the 17 panel members and has been labeled according to the 3 appropriate use categories of appropriate, uncertain, and inappropriate. Tables 8 to 10 present the indications by these categories. Algorithm Figures 1 to 10 describe the application of criteria as presented in these tables.

A majority of ratings were in agreement as defined in the preceding text, including 66% of appropriate and 55% of inappropriate indications. In contrast, only 7% of indications rated as uncertain showed agreement, indicating greater diversity of opinion on these indications. Only 2 of the 93 indications (Indications 1 [low] and 15 [low], both of which were rated as uncertain), were statistically classified as being in disagreement. Because these indications were already placed in the uncertain category, no changes were required to reflect disagreement.

7. Cardiac Computed Tomography Appropriate Use Criteria (By Indication)

Table 1. Detection of CAD in Symptomatic Patients Without Known Heart Disease*

Indication		Appropriate Use Score (1–9)		
Nonacute Symptoms Possibly Representing an Ischemic Equivalent				
	Pretest Probability of CAD	**Low**	**Intermediate**	**High**
1.	• ECG interpretable AND • Able to exercise	U (5)	A (7)	I (3)
2.	• ECG uninterpretable OR • Unable to exercise	A (7)	A (8)	U (4)
Acute Symptoms With Suspicion of ACS (Urgent Presentation)				
3.	• Definite MI	I (1)		
4.	• Persistent ECG ST-segment elevation following exclusion of MI	U (6)		
5.	• Acute chest pain of uncertain cause (differential diagnosis includes pulmonary embolism, aortic dissection, and ACS [“triple rule out”])	U (6)		
	Pretest Probability of CAD	**Low**	**Intermediate**	**High**
6.	• Normal ECG and cardiac biomarkers	A (7)	A (7)	U (4)
7.	• ECG uninterpretable	A (7)	A (7)	U (4)
8.	• Nondiagnostic ECG OR • Equivocal cardiac biomarkers	A (7)	A (7)	U (4)

*Note: All indications are for CTA unless otherwise noted.
A indicates appropriate; I, inappropriate; and U, uncertain.

Table 2. Detection of CAD/Risk Assessment in Asymptomatic Patients Without Known CAD

Indication		Appropriate Use Score (1–9)		
Noncontrast CT for CCS				
	Global CHD Risk Estimate	**Low**	**Intermediate**	**High**
9.	• Family history of premature CHD	A (7)		
10.	• Asymptomatic • No known CAD	I (2)	A (7)	U (4)
Coronary CTA				
	Global CHD Risk Estimate	**Low**	**Intermediate**	**High**
11.	• Asymptomatic • No known CAD	I (2)	I (2)	U (4)
Coronary CTA Following Heart Transplantation				
12.	• Routine evaluation of coronary arteries	U (6)		

A indicates appropriate; I, inappropriate; and U, uncertain.

Table 3. Detection of CAD in Other Clinical Scenarios

Indication		Appropriate Use Score (1–9)		
New-Onset or Newly Diagnosed Clinical HF and No Prior CAD				
	Pretest Probability of CAD	**Low**	**Intermediate**	**High**
13.	• Reduced left ventricular ejection fraction	A (7)	A (7)	U (4)
14.	• Normal left ventricular ejection fraction	U (5)	U (5)	U (4)
Preoperative Coronary Assessment Prior to Noncoronary Cardiac Surgery				
	Pretest Probability of CAD	**Low**	**Intermediate**	**High**
15.	• Coronary evaluation before noncoronary cardiac surgery	U (6)	A (7)	I (3)
Arrhythmias—Etiology Unclear After Initial Evaluation				
16.	• New-onset atrial fibrillation (atrial fibrillation is underlying rhythm during imaging)	I (2)		
17.	• Nonsustained ventricular tachycardia	U (6)		
18.	• Syncope	U (4)		
Elevated Troponin of Uncertain Clinical Significance				
19.	• Elevated troponin without additional evidence of ACS or symptoms suggestive of CAD	U (6)		

A indicates appropriate; I, inappropriate; and U, uncertain.

Table 4. Use of CTA in the Setting of Prior Test Results

Indication		Appropriate Use Score (1–9)			
Prior ECG Exercise Testing					
20.	• Prior normal ECG exercise test • Continued symptoms	A (7)			
Duke Treadmill Score—Risk Findings		**Low**	**Intermediate**	**High**	
21.	• Prior ECG exercise testing	I (2)	A (7)	I (3)	
Sequential Testing After Stress Imaging Procedures					
22.	• Discordant ECG exercise and imaging results	A (8)			
Test Result/Ischemia		**Equivocal**	**Mild**	**Moderate or Severe**	
23.	• Prior stress imaging procedure	A (8)	U (6)	I (2)	
Prior CCS					
24.	• Zero CCS >5 y ago	U (4)			
25.	• Positive CCS >2 y ago	I (2)			
CCS		**<100**	**100–400**	**401–1000**	**>1000**
26.	Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients	A (8)	A (8)	U (6)	U (4)
Asymptomatic OR Stable Symptoms Periodic Repeat Testing in the Setting of Prior Stress Imaging or Prior Coronary Angiography					
Last Study Done		**<2 y Ago**	**≥2 y Ago**		
27.	• No known CAD	I (2)	I (3)		
28.	• Known CAD	I (2)	I (3)		
Evaluation of New or Worsening Symptoms in the Setting of Past Stress Imaging Study					
Previous Stress Imaging Study		**Normal**	**Abnormal**		
29.	• Evaluation of new or worsening symptoms	A (8)	U (6)		

A indicates appropriate; I, inappropriate; and U, uncertain.

Table 5. Risk Assessment Preoperative Evaluation of Noncardiac Surgery Without Active Cardiac Conditions

Indication		Appropriate Use Score (1–9)
Low-Risk Surgery		
30.	• Preoperative evaluation for noncardiac surgery risk assessment, irrespective of functional capacity	I (1)
Intermediate-Risk Surgery		
31.	• No clinical risk predictors	I (2)
32.	• Functional capacity ≥4 METs	I (2)
33.	• Functional capacity <4 METs with 1 or more clinical risk predictors	U (5)
34.	• Asymptomatic <1 y following a normal coronary angiogram, stress test, or a coronary revascularization procedure	I (1)
Vascular Surgery		
35.	• No clinical risk predictors	I (2)
36.	• Functional capacity ≥4 METs	I (2)
37.	• Functional capacity <4 METs with 1 or more clinical risk predictors	U (6)
38.	• Asymptomatic <1 y following a normal coronary angiogram, stress test, or a coronary revascularization procedure	I (2)

A indicates appropriate; I, inappropriate; and U, uncertain.

Table 6. Risk Assessment Postrevascularization (PCI or CABG)

Indication		Appropriate Use Score (1–9)	
Symptomatic (Ischemic Equivalent)			
39.	• Evaluation of graft patency after CABG	A (8)	
40.	• Prior coronary stent with stent diameter <3 mm or not known	I (3)	
41.	• Prior coronary stent with stent diameter ≥3 mm	U (6)	
Asymptomatic—CABG			
Time Since CABG		**<5 y Ago**	**≥5 y Ago**
42.	• Prior CABG	I (2)	U (5)
Asymptomatic—Prior Coronary Stenting			
43.	• Prior left main coronary stent • Stent diameter ≥3 mm	A (7)	
Time Since PCI		**<2 y**	**≥2 y**
44.	• Stent diameter <3 mm or not known	I (2)	I (2)
45.	• Stent diameter ≥3 mm	I (3)	U (4)

A indicates appropriate; I, inappropriate; and U, uncertain.

Table 7. Evaluation of Cardiac Structure and Function

Indication		Appropriate Use Score (1–9)
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 Ventricular Morphology and Systolic Function		
48.	• Initial evaluation of left ventricular function • Following acute MI or in HF patients	I (2)
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)
52.	• Assessment of myocardial viability • Prior to myocardial revascularization for ischemic left ventricular systolic dysfunction • Other imaging modalities are inadequate or contraindicated	U (5)
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)
55.	• Initial evaluation of cardiac mass (suspected tumor or thrombus)	I (3)
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)

A indicates appropriate; I, inappropriate; and U, uncertain.

8. Cardiac Computed Tomography Appropriate Use Criteria (By Appropriate Use Criteria)

Table 8. Appropriate Indications (Median Score 7–9)

Indication		Appropriate Use Score (1–9)
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)
2.	• 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.	• Normal ECG and cardiac biomarkers • Low pretest probability of CAD	A (7)
6.	• Normal ECG and cardiac biomarkers • Intermediate pretest probability of CAD	A (7)
7.	• ECG uninterpretable • Low pretest probability of CAD	A (7)
7.	• ECG uninterpretable • Intermediate pretest probability of CAD	A (7)
8.	• Nondiagnostic ECG or equivocal cardiac biomarkers • Low pretest probability of CAD	A (7)
8.	• Nondiagnostic ECG or equivocal cardiac biomarkers • Intermediate pretest probability of CAD	A (7)
Detection of CAD/Risk Assessment in Asymptomatic Individuals Without Known CAD—Noncontrast CT for CCS		
9.	• Family history of premature CHD • Low global CHD risk estimate	A (7)
10.	• Asymptomatic • No known CAD • Intermediate global CHD risk estimate	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 • Low pretest probability of CAD	A (7)
13.	• 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.	• 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.	• Normal ECG exercise test • Continued symptoms	A (7)
21.	• 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.	• Discordant ECG exercise and imaging results	A (8)
23.	• Stress imaging results: equivocal	A (8)
Use of CTA in the Setting of Prior Test Results—Prior CCS		
26.	• Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients • CCS <100	A (8)
26.	• Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients • CCS 100–400	A (8)
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)

Table 8. Continued

	Indication	Appropriate Use Score (1–9)
	Risk Assessment Postrevascularization (PCI or CABG)—Asymptomatic—Prior Coronary Stenting	
43.	• Prior left main coronary stent with stent diameter ≥3 mm	A (7)
	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)

A indicates appropriate; I, inappropriate; and U, uncertain.

Table 9. Uncertain Indications (Median Score 4–6)

	Indication	Appropriate Use Score (1–9)
	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 • Low pretest probability of CAD	U (5)
2.	• ECG uninterpretable or unable to exercise • High pretest probability of CAD	U (4)
	Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic—Acute Symptoms With Suspicion of ACS (Urgent Presentation)	
4.	• Persistent ECG ST-segment elevation following exclusion of MI	U (6)
5.	• Acute chest pain of uncertain cause (differential diagnosis includes pulmonary embolism, aortic dissection, and ACS [“triple rule out”])	U (6)
6.	• Normal ECG and cardiac biomarkers • High pretest probability of CAD	U (4)
7.	• ECG uninterpretable • High pretest probability of CAD	U (4)
8.	• Nondiagnostic ECG or equivocal cardiac biomarkers • High pretest probability of CAD	U (4)
	Detection of CAD/Risk Assessment in Asymptomatic Individuals Without Known CAD—Noncontrast CT for CCS	
10.	• Asymptomatic • No known CAD • High global CHD risk estimate	U (4)

Table 9. Continued

	Indication	Appropriate Use Score (1–9)
Detection of CAD/Risk Assessment in Asymptomatic Individuals Without Known CAD—Coronary CTA		
11.	• Asymptomatic • No known CAD • High global CHD risk estimate	U (4)
Detection of CAD/Risk Assessment in Asymptomatic Individuals Without Known CAD—Coronary CTA Following Heart Transplantation		
12.	• Routine evaluation of coronary arteries	U (6)
Detection of CAD in Other Clinical Scenarios—New-Onset or Newly Diagnosed Clinical HF and No Prior CAD		
13.	• Reduced left ventricular ejection fraction • High pretest probability of CAD	U (4)
14.	• Normal left ventricular ejection fraction • Low pretest probability of CAD	U (5)
14.	• Normal left ventricular ejection fraction • Intermediate pretest probability of CAD	U (5)
14.	• Normal left ventricular ejection fraction • High pretest probability of CAD	U (4)
Detection of CAD in Other Clinical Scenarios—Preoperative Coronary Assessment Prior to Noncoronary Cardiac Surgery		
15.	• Coronary evaluation before noncoronary cardiac surgery • Low pretest probability of CAD	U (6)
Detection of CAD in Other Clinical Scenarios—Arrhythmias—Etiology Unclear After Initial Evaluation		
17.	• Nonsustained ventricular tachycardia	U (6)
18.	• Syncope	U (4)
Detection of CAD in Other Clinical Scenarios—Elevated Troponin of Uncertain Clinical Significance		
19.	• Elevated troponin without additional evidence of ACS or symptoms suggestive of CAD	U (6)
Use of CTA in the Setting of Prior Test Results—Sequential Testing After Stress Imaging Procedures		
23.	• Stress imaging results: mild ischemia	U (6)
Use of CTA in the Setting of Prior Test Results—Prior CCS		
24.	• Zero CCS >5 y ago	U (4)
26.	• Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients • CCS 401–1000	U (6)
26.	• Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients • CCS >1000	U (4)
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 abnormal	U (6)
Risk Assessment Preoperative Evaluation of Noncardiac Surgery Without Active Cardiac Conditions—Intermediate-Risk Surgery		
33.	• Functional capacity <4 METs with 1 or more clinical risk predictors	U (5)
Risk Assessment Preoperative Evaluation of Noncardiac Surgery Without Active Cardiac Conditions—Vascular Surgery		
37.	• Functional capacity <4 METs with 1 or more clinical risk predictors	U (6)
Risk Assessment Postrevascularization (PCI or CABG)—Symptomatic (Ischemic Equivalent)		
41.	• Prior coronary stent with stent diameter ≥3 mm	U (6)
Risk Assessment Postrevascularization (PCI or CABG)—Asymptomatic—CABG		
42.	• Prior coronary bypass surgery ≥5 y ago	U (5)
Risk Assessment Postrevascularization (PCI or CABG)—Asymptomatic—Prior Coronary Stenting		
44.	• Stent diameter ≥3 mm • Greater than or equal to 2 y after PCI	U (4)
Evaluation of Cardiac Structure and Function—Evaluation of Ventricular Morphology and Systolic Function		
52.	• Assessment of myocardial viability prior to myocardial revascularization • Ischemic left ventricular systolic dysfunction • Other imaging modalities are inadequate or contraindicated	U (5)

A indicates appropriate; I, inappropriate; and U, uncertain.

Table 10. Inappropriate Indications (Median Score 1–3)

	Indication	Appropriate Use Score (1–9)
	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 • High pretest probability of CAD	I (3)
	Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic—Acute Symptoms With Suspicion of ACS (Urgent Presentation)	
3.	• Definite MI	I (1)
	Detection of CAD/Risk Assessment in Asymptomatic Individuals Without Known CAD—Noncontrast CT for CCS	
10.	• Low global CHD risk estimate	I (2)
	Detection of CAD/Risk Assessment in Asymptomatic Individuals Without Known CAD—Coronary CTA	
11.	• Low global CHD risk estimate	I (2)
11.	• Intermediate global CHD risk estimate	I (2)
	Detection of CAD in Other Clinical Scenarios—Preoperative Coronary Assessment Prior to Noncoronary Cardiac Surgery	
15.	• Coronary evaluation before noncoronary cardiac surgery • High global CHD risk estimate	I (3)
	Detection of CAD in Other Clinical Scenarios—Arrhythmias—Etiology Unclear After Initial Evaluation	
16.	• New-onset atrial fibrillation (atrial fibrillation is underlying rhythm during imaging)	I (2)
	Use of CTA in the Setting of Prior Test Results—ECG Exercise Testing	
21.	• Exercise ECG testing • Duke Treadmill Score—low-risk findings	I (2)
21.	• Exercise ECG testing • Duke Treadmill Score—high-risk findings	I (3)
	Use of CTA in the Setting of Prior Test Results—Sequential Testing After Stress Imaging Procedures	
23.	• Stress imaging results: moderate or severe ischemia	I (2)
	Use of CTA in the Setting of Prior Test Results—Prior CCS	
25.	• Positive calcium score >2 y ago	I (2)
	Periodic Repeat Testing in Asymptomatic OR Stable Symptoms With Prior Stress Imaging or Coronary Angiography	
27.	• No known CAD • Last study done <2 y ago	I (2)
27.	• No known CAD • Last study done ≥2 y ago	I (3)
28.	• Known CAD • Last study done <2 y ago	I (2)
28.	• Known CAD • Last study done ≥2 y ago	I (3)
	Risk Assessment Preoperative Evaluation of Noncardiac Surgery Without Active Cardiac Conditions—Low-Risk Surgery	
30.	• Preoperative evaluation for noncardiac surgery risk assessment, irrespective of functional capacity	I (1)
	Risk Assessment Preoperative Evaluation of Noncardiac Surgery Without Active Cardiac Conditions—Intermediate-Risk Surgery	
31.	• No clinical risk predictors	I (2)
32.	• Functional capacity ≥4 METs	I (2)
34.	• Asymptomatic <1 y following a normal coronary angiogram, stress test, or a coronary revascularization procedure	I (1)
	Risk Assessment Preoperative Evaluation of Noncardiac Surgery Without Active Cardiac Conditions—Vascular Surgery	
35.	• No clinical risk predictors	I (2)
36.	• Functional capacity ≥4 METs	I (2)
38.	• Asymptomatic <1 y following a normal coronary angiogram, stress test, or a coronary revascularization procedure	I (2)
	Risk Assessment Postrevascularization (PCI or CABG)—Symptomatic (Ischemic Equivalent)	
40.	• Prior coronary stent with stent diameter <3 mm or not known	I (3)
	Risk Assessment Postrevascularization (PCI or CABG)—Asymptomatic—CABG	
42.	• Prior coronary bypass surgery <5 y ago	I (2)

Table 10. Continued

Indication		Appropriate Use Score (1–9)
Risk Assessment Postrevascularization (PCI or CABG)—Asymptomatic—Prior Coronary Stenting		
44.	• Prior coronary stent with stent diameter <3 mm or not known • Less than 2 y after PCI	I (2)
44.	• Prior coronary stent with stent diameter <3 mm or not known • Greater than or equal to 2 y after PCI	I (2)
45.	• Prior coronary stent with stent diameter ≥3 mm • Less than 2 y after PCI	I (3)
Evaluation of Cardiac Structure and Function—Evaluation of Ventricular Morphology and Systolic Function		
48.	• Initial evaluation of left ventricular function • Following acute MI or in HF patients	I (2)
Evaluation of Cardiac Structure and Function—Evaluation of Intra- and Extracardiac Structures		
55.	• Initial evaluation of cardiac mass (suspected tumor or thrombus)	I (3)

A indicates appropriate; I, inappropriate; and U, uncertain.

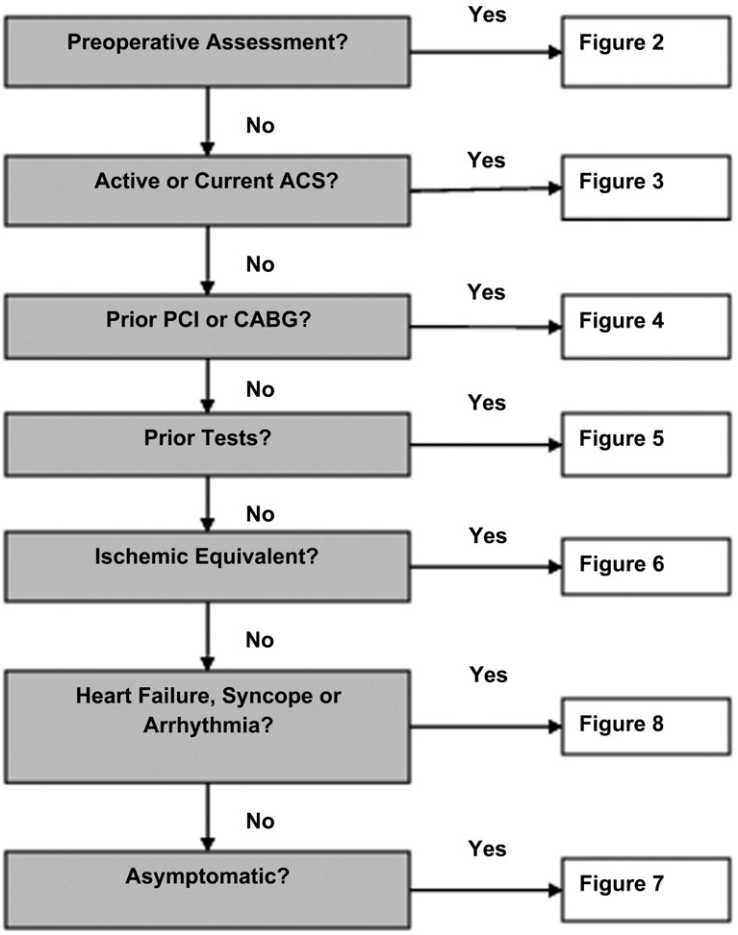

Figure 1. Hierarchy of Potential Test Ordering Based on Clinical Presentation

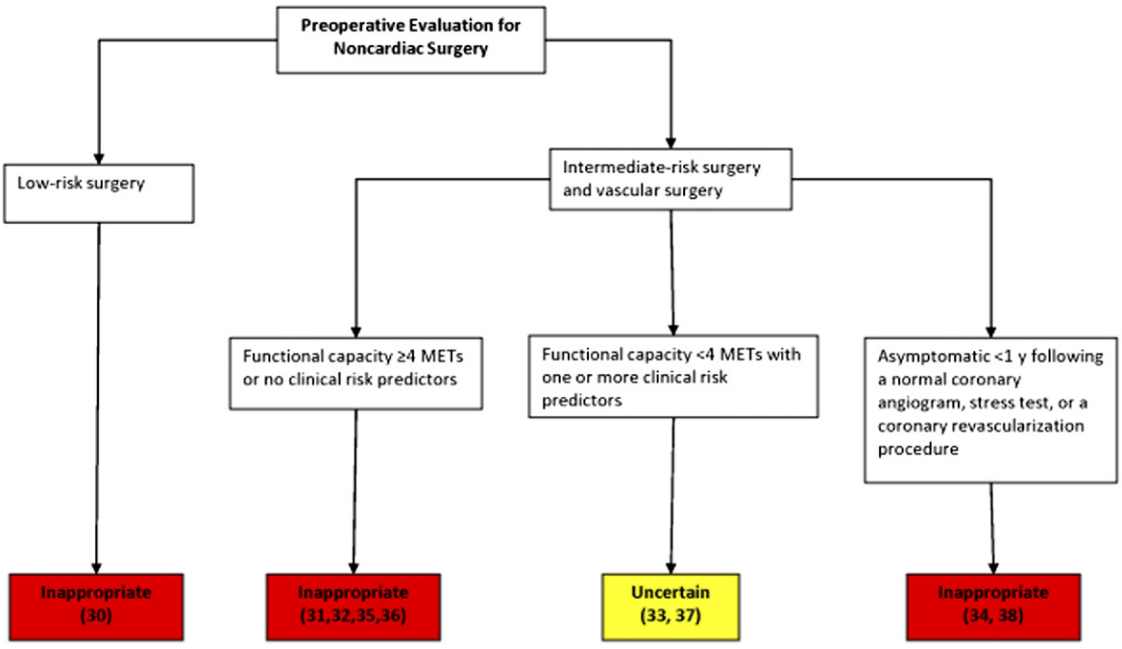

Figure 2. Risk Assessment Preoperative Evaluation of Noncardiac Surgery

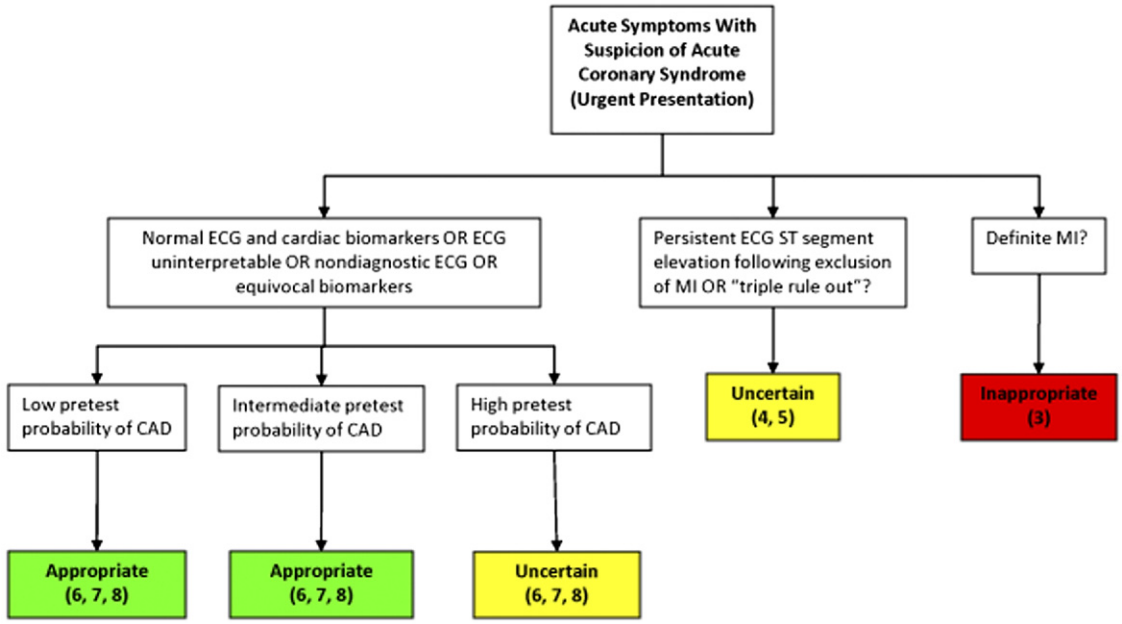

Figure 3. Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic Acute Presentation

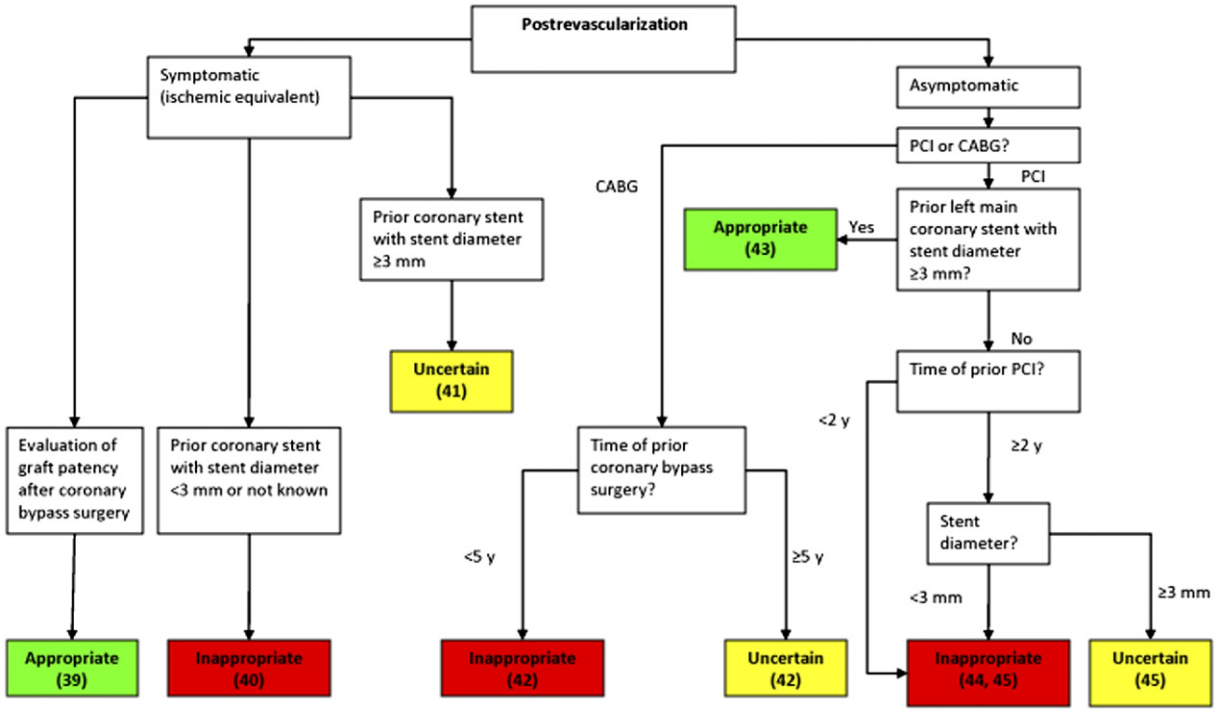

Figure 4. Risk Assessment Postrevascularization (PCI or CABG)

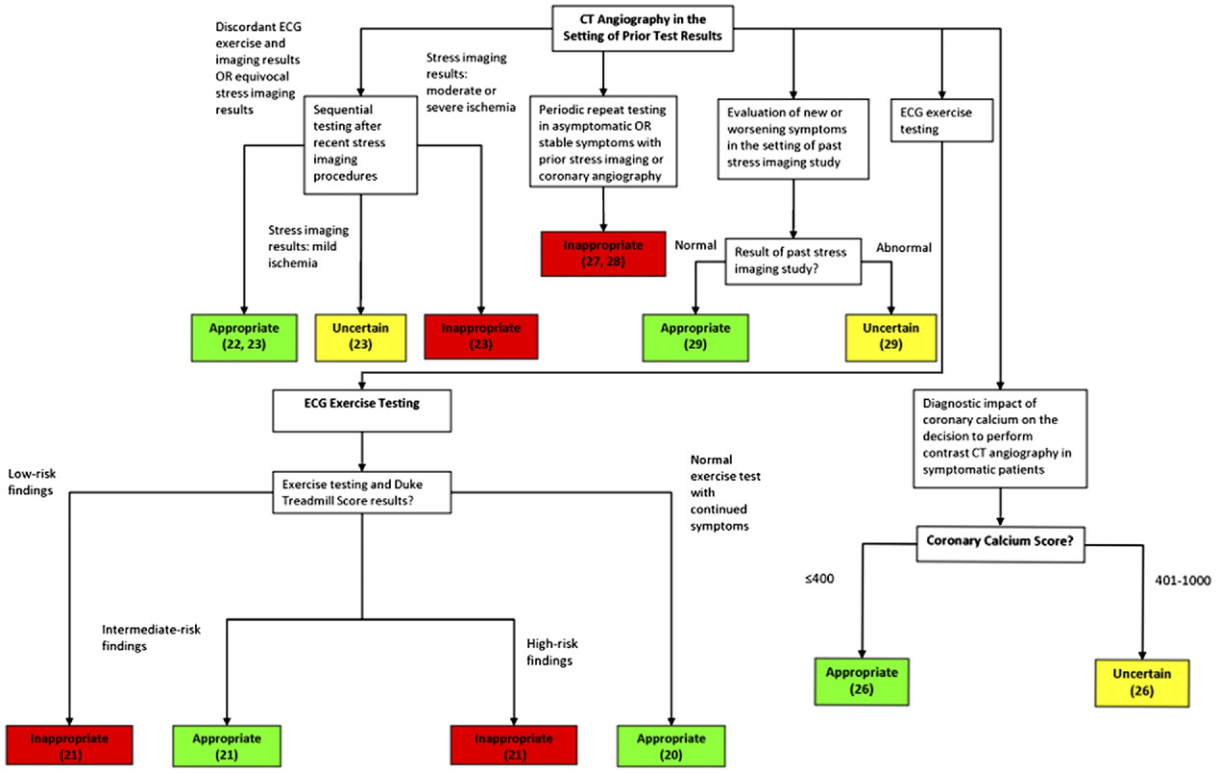

Figure 5. Use of CT Angiography in the Setting of Prior Test Results

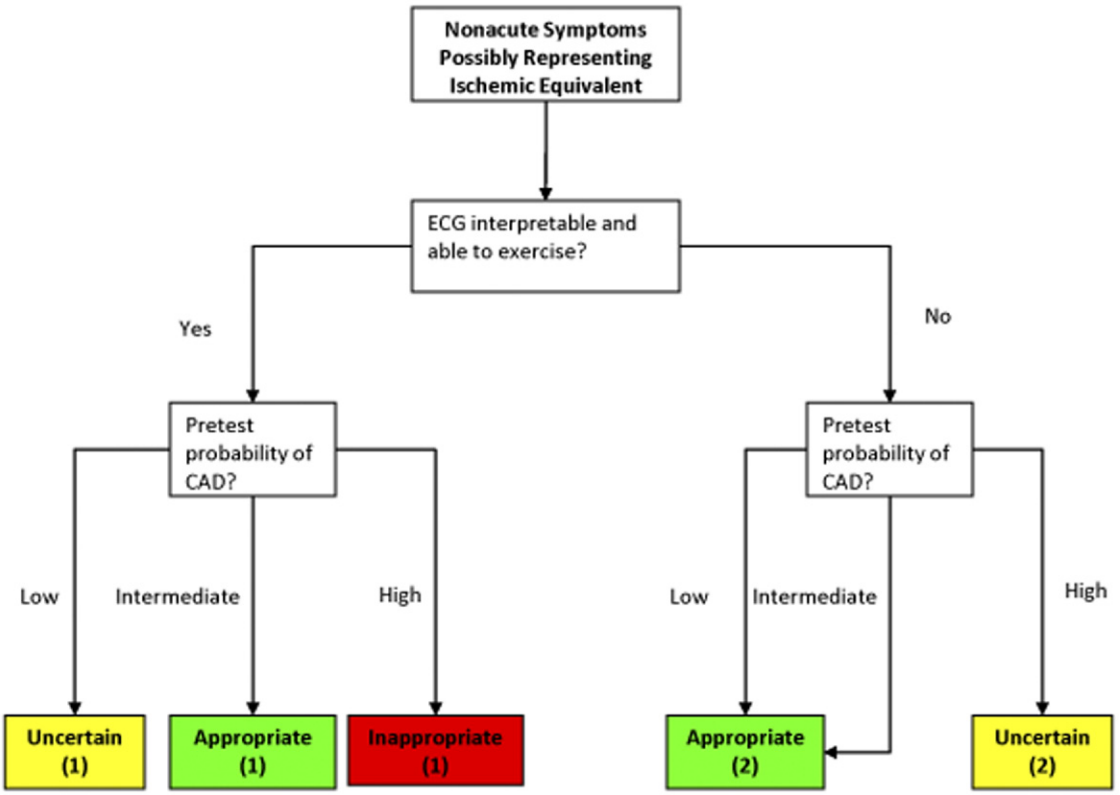

Figure 6. Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic—Nonacute Presentation

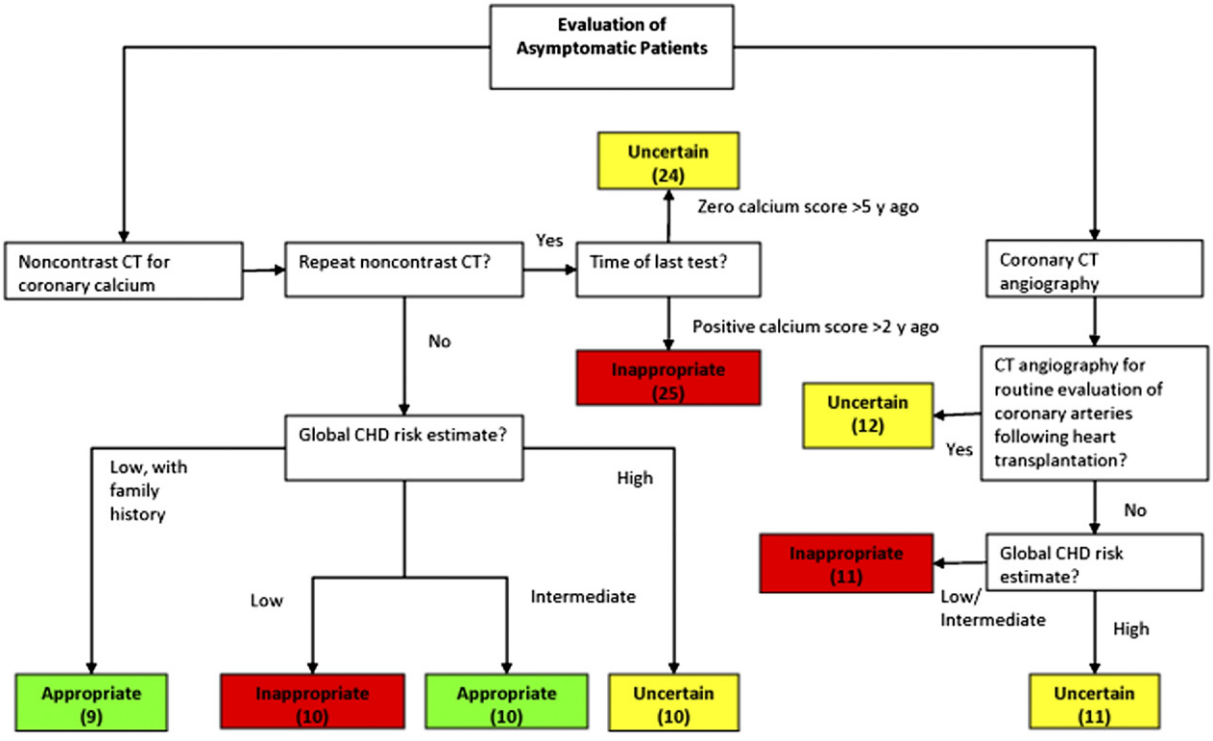

Figure 7. Detection of CAD/Risk Assessment in Asymptomatic Individuals Without Known Coronary Artery Disease

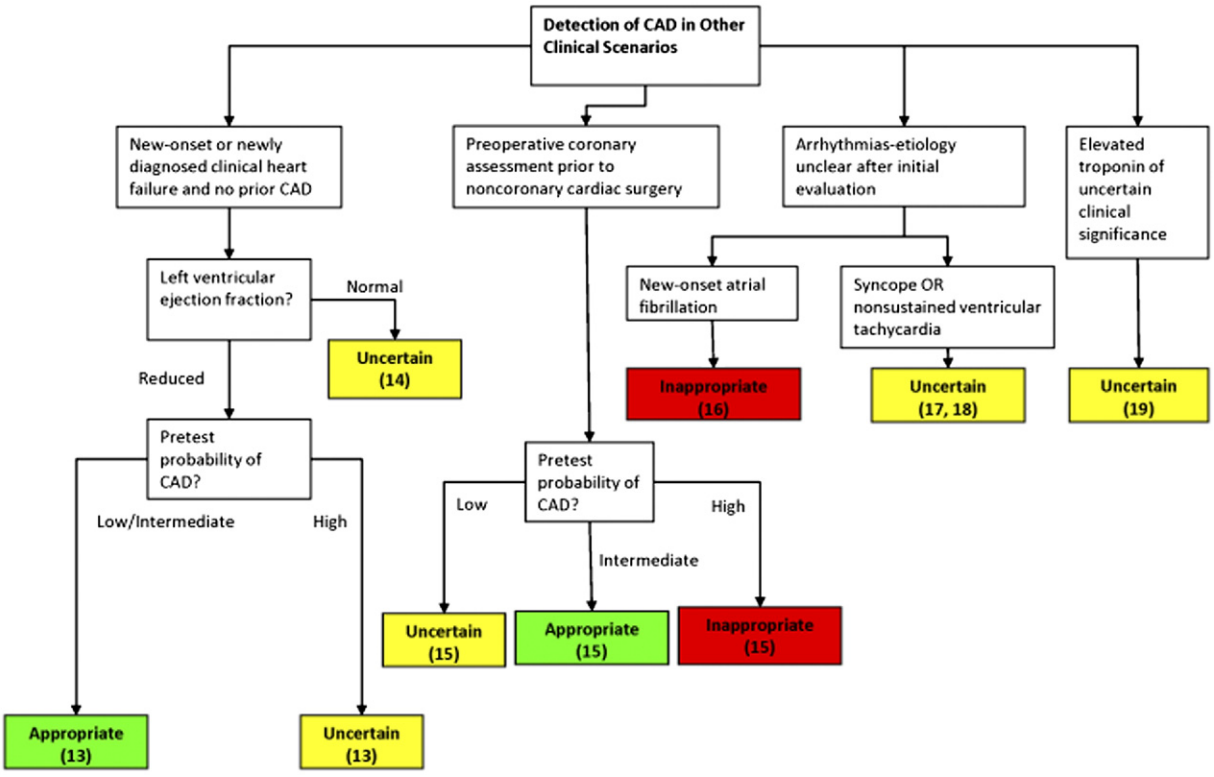

Figure 8. Detection of CAD in Other Clinical Scenarios

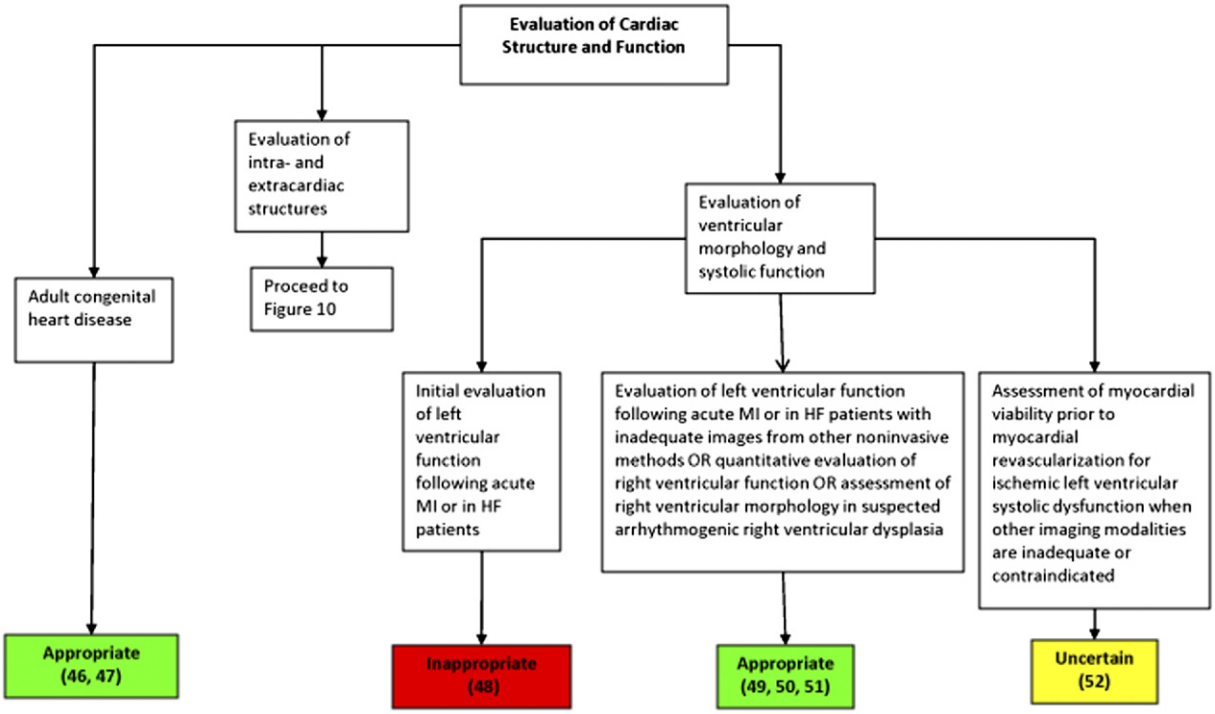

Figure 9. Evaluation of Cardiac Structure and Function

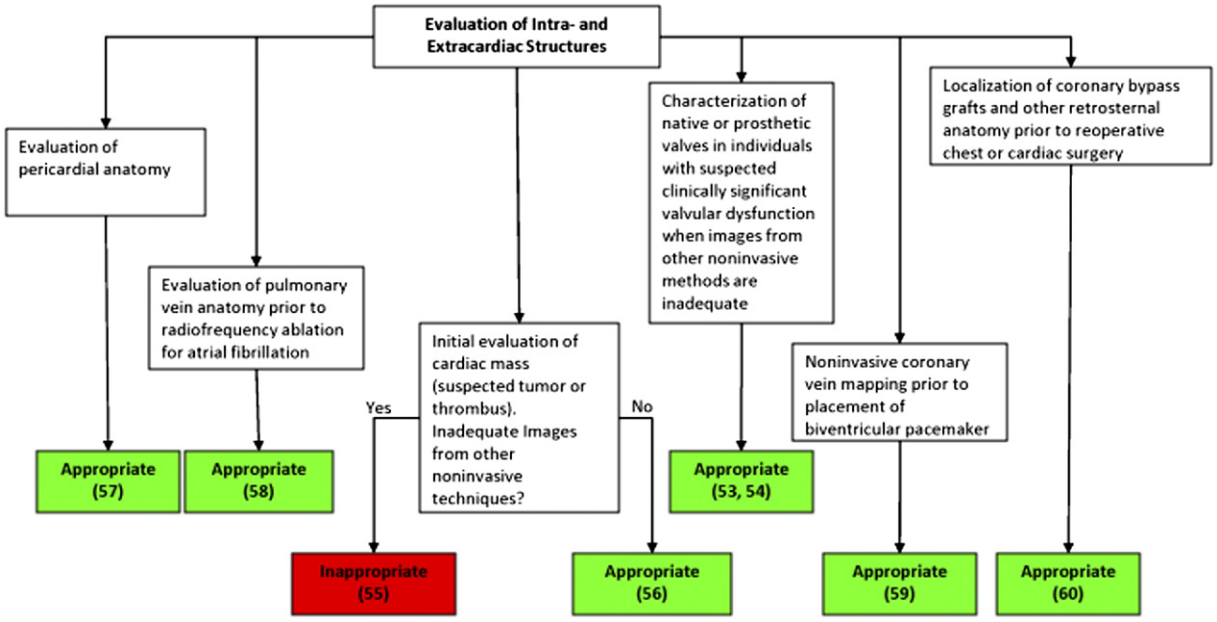

Figure 10. Evaluation of Cardiac Structure and Function: Evaluation of Intra- and Extracardiac Structures

9. Discussion

Appropriate use criteria define common patient subgroups where expert opinion and the available medical evidence are combined to assess the net benefit of a test or procedure, in this instance CCT. The intent of these criteria is to guide the rational use of the procedure, namely avoidance of either under- or overutilization, and thereby lead to more optimal healthcare delivery and justifiable healthcare expenditures.

This document is an update to the original appropriateness criteria for CCT published in 2006 (1), written to reflect changes in test utilization in the context of rapidly developing technical and clinical applications and within the conceptual framework of dynamic appropriate use criteria development. Several aspects of the present document are noteworthy, including careful alignment to and, where possible, definition of language in the radionuclide imaging appropriate use criteria (2) to enhance integration into comparable decision support tools and performance metrics. The underlying assumptions for the document are intended to broadly reflect the present community standards of technology and performance of the technique with an emphasis on adherence to imaging guidelines, patient safety, and laboratory quality and accreditation.

The clinical scenarios included in this report were designed to reflect the most common and important potential applications for CCT imaging. After the initial writing by the writing group, extensive review from external editors, and then ranking by the technical panel itself, the result is a set of scenarios that define patient-specific applications. The appropriate use criteria in this report provide a consensus judgment of whether it is reasonable to use CCT imaging for the particular clinical scenario described, such as those 93 indications listed in this document. These criteria are expected to be useful for clinicians, healthcare facilities, and third-party payers engaged in the delivery of cardiovascular imaging services. Although numerous, the indications are commonly divided among subclasses of patient CHD risk or pretest probability of CAD, as such characteristics are important considerations within the test performance characteristics. In total, 35 of 93 indications were judged to be appropriate, and 58 were judged to be either inappropriate or uncertain. It is important to note however, that an understanding of pretest patient characteristics is an important determinant of the appropriate use ratings. Few categories are uniform in the ratings for all patient characteristics.

Appropriate use criteria represent the first component of the chain of quality recommendations for cardiovascular imaging (15). In addition to appropriate use, patient safety also should be considered when ordering coronary computed tomographic angiography (CTA), as it should be when ordering any cardiac imaging test. A consideration of the appropriate balance of using radiation dose reduction techniques to minimize radiation exposure while preserving image quality and the related benefits of imaging for a specific patient should be undertaken. This issue is discussed in more depth in a 2010 expert consensus document on coronary CTA (16). The present document greatly expands the number of potential clinical scenarios in comparison to the original 2006 document. The clinical scenarios include acute and chronic chest pain, testing in symptomatic and asymptomatic patients, heart failure, preoperative risk assessment before both cardiac and noncardiac surgery, testing

in the setting of prior test results (exercise testing, stress imaging procedures, coronary calcium scores, and repeat testing), prior revascularization, and the evaluation of cardiac structure and function. Although these criteria are intended to provide guidance for patients and clinicians, they are not intended to serve as substitutes for sound clinical judgment and practice experience. The writing group recognizes that many patients encountered in clinical practice may not be represented in these appropriate use criteria or may have extenuating features when compared with the clinical scenarios presented. Although the appropriate use ratings reflect critical medical literature as well as expert consensus, physicians and other stakeholders should understand the role of clinical judgment in determining whether to order a test for an individual patient. Additionally, uncertain indications often require individual physician judgment and understanding of the patient to better determine the usefulness of a test for a particular scenario. As such, the ranking of an indication as uncertain (4 to 6) should not be viewed as limiting the use of CCT imaging for such patients. It should be emphasized that the technical panel was instructed that the uncertain designation was still designed to be considered as a "reimbursable" category.

These ratings are intended to evaluate the appropriate use of specific patient scenarios to determine overall **patterns of care** regarding CCT. In situations where there is substantial variation between the appropriate use rating and what the clinician believes is the best recommendation for the patient, further considerations or actions, such as a second opinion, may be appropriate. Moreover, it is not anticipated that all physicians or facilities will have 100% of their CCT procedures deemed appropriate. However, related to the overall patterns of care, if the national average of appropriate and uncertain ratings is 80%, for example, and a physician or facility has a 40% rate of inappropriate procedures, further examination of the patterns of care may be warranted and helpful. Implementation of these criteria is highly encouraged through provider education, as it is anticipated that increasing emphasis by laboratory accreditation bodies and other organizations focused on provider quality will apply.

9.1. Clinical Scenarios and Their Ratings

Direct comparison to the 2006 document is difficult because of the many changes in the number and wording of clinical scenarios. In summary:

- A total of 31 indications were carried forward from the 2006 document, including prior ratings where 10 were appropriate, 10 were uncertain, and 11 were inappropriate. Among these, 8 shifted up 1 category from either uncertain to appropriate (Indications 1 [intermediate], 6 [low], 10 [intermediate], 39, 49, 54) or from inappropriate to uncertain (Indications 2 [high], 42 [>5 y]). The other 23 indications had unchanged appropriate use ratings.
- One area of expansion compared with the 2006 criteria involves symptomatic patients without known heart disease. CCT was felt to be appropriate primarily for situations involving a low or intermediate pretest probability of obstructive CAD. Scenarios involving high-probability CAD patients were rated as uncertain with the exceptions of a patient with an interpretable ECG who was able to exercise, and for definite myocardial infarction.
- Noncontrast CT calcium scoring was judged as appropriate for intermediate CHD risk patients, and for the specific subset of low-risk patients in whom a family history of premature CHD was present. Intermediate risk was defined as a 10-year risk of between 10% and 20%, although individual patient exceptions to a broadened intermediate risk range of 6% to 20% were recognized for certain patient subsets with generally low absolute risk but high relative risk (younger men and women). Screening asymptomatic patients using coronary CT angiography was considered inappropriate, as was repeat coronary calcium testing. Repeat CT angiography in asymptomatic patients or patients with stable symptoms with prior test results was broadly considered inappropriate.
- Within heart failure, CT angiography was appropriate or uncertain as a test across both normal (new to this document) and abnormal left ventricular ejection fraction, although the only appropriate scenarios were with reduced left ventricular ejection fraction with low or intermediate pretest CAD probability.
- As part of the preoperative evaluation, CT angiography was viewed as a potential option among patients undergoing heart surgery for noncoronary indications (e.g., valve replacement surgery or atrial septal defect closure) when the pretest CAD risk was either intermediate (appropriate) or low (uncertain). In comparison, there were no appropriate indications for coronary CT angiography as part of the preoperative evaluation for noncardiac surgery.
- The evaluation of coronary stents was considered as a function of patient symptom status, time from revascularization, and stent size. Only with larger stents (≥3 mm in diameter) after long time periods (≥2 years) was stent imaging considered uncertain, and only with left main stents was imaging of stents considered appropriate.
- A strength of cardiac CT imaging is the evaluation of cardiac structure and function. Appropriate indications include coronary anomalies, congenital heart disease, evaluation of right ventricular function, evaluation of left ventricular ejection fraction when images from other techniques are inadequate, or evaluation of prosthetic heart valves. New to this document is the use of CCT for evaluation of myocardial viability when other modalities are inadequate or contraindicated

(uncertain), and in suspected arrhythmogenic right ventricular dysplasia (appropriate).

- The use of CCT was appropriate prior to electrophysiological procedures for anatomic mapping, or prior to repeat sternotomy in reoperative cardiac surgery.
- There was disagreement on the panel in 2 of the clinical scenarios: 1) detection of CAD in the setting of a low pretest probability for CAD when the ECG is interpretable and the patient is able to exercise (Indication 1); and 2) preoperative coronary assessment prior to noncoronary cardiac surgery in the setting of a low pretest probability for CAD (Indication 30). Both of these indications were ranked in the uncertain category.

9.2. Application of Criteria

There are many potential applications for appropriate use criteria. Clinicians could use the ratings for decision support or an educational tool when considering the need for CCT imaging. Moreover, these criteria could be used to facilitate discussion with patients and/or referring physicians about the need for CCT imaging. Facilities and payers may choose to use these criteria either prospectively in the design of protocols and preauthorization procedures, or retrospectively for quality reports. It is hoped that payers would use these criteria as the basis for the development of rational payment management strategies.

These criteria were developed with the intent that they be considered in both the delivery and in the policy positions for these services, including reimbursement. In contrast, services performed for inappropriate indications should likely require additional documentation to justify reimbursement because of the unique circumstances or the clinical profile that must exist in such a patient. It is critical to emphasize that the writing group, technical panel, Appropriate Use Criteria Task Force, and clinical community do not believe an uncertain rating is grounds to deny reimbursement for CCT imaging. Rather, uncertain ratings are those where expert opinion or the available data vary or are rapidly evolving. The opinions of the technical panel often varied for these indications reflecting that additional research is needed. By the same right, appropriate indications

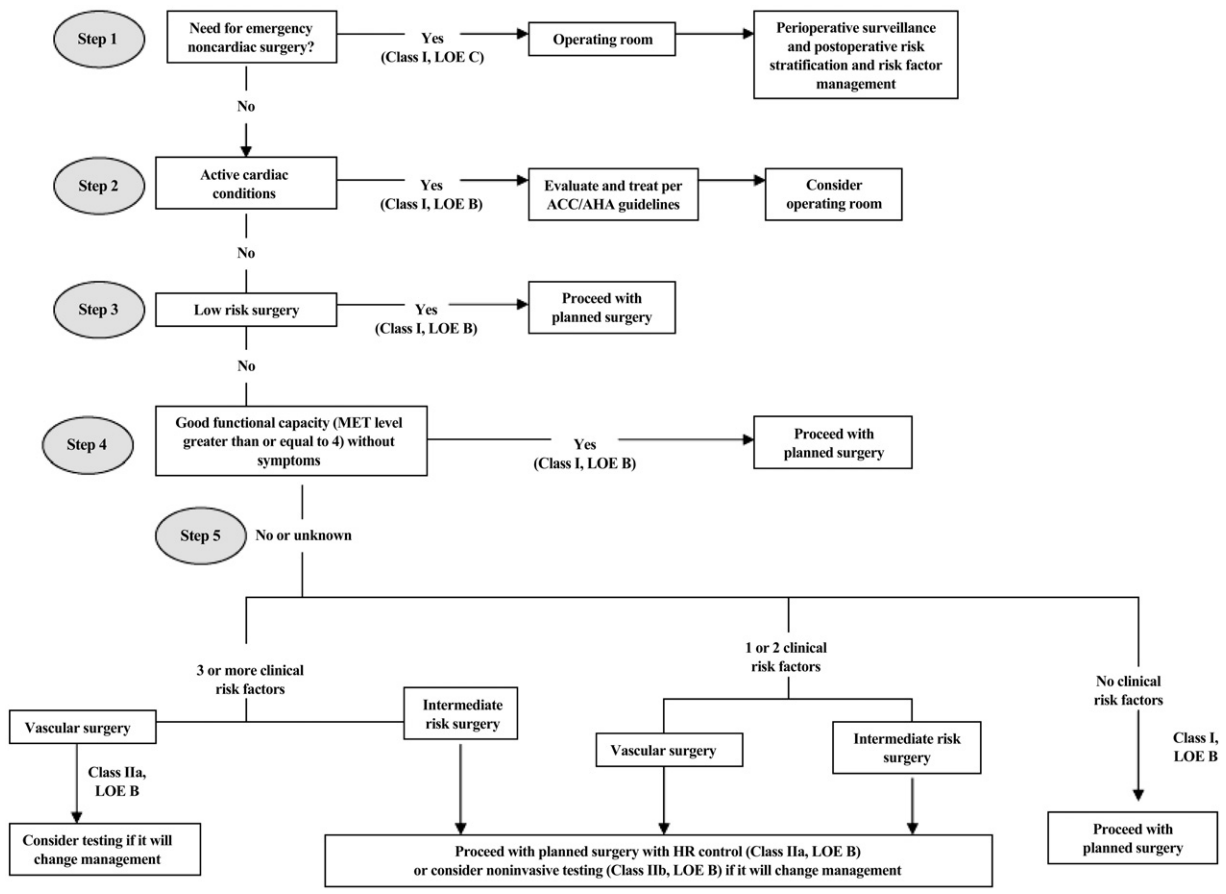

Figure A1. Stepwise Approach to Perioperative Cardiac Assessment

Cardiac evaluation and care algorithm for noncardiac surgery based on active clinical conditions, known cardiovascular disease, or cardiac risk factors for patients ≥50 years of age. HR indicates heart rate; LOE, level of evidence; and MET, metabolic equivalent. Modified from Fleisher (19).

may still benefit from further clinical trials and evidence development.

In conclusion, this document represents the current understanding of the net clinical benefit of CCT imaging with respect to the balance between benefit and risk to the patient as assessed under the ACCF's appropriate use criteria methodology. It is intended to provide a practical guide and perspective to clinicians and patients when considering CCT imaging and promote more appropriate test utilization including avoidance of either under- or overutilization. As with other appropriate use criteria, some of these ratings will require research and further evaluation to provide the greatest information and benefit to clinical decision making. Finally, it will be necessary to periodically assess and update the indications and criteria as technology evolves and new data and field experience become available.

Appendix A: Additional Cardiac Computed Tomography Definitions

Angina: As defined by the ACC/AHA Guidelines on Exercise Testing (9)

- ***Typical* Angina (Definite):**
  1. Substernal chest pain, or an ischemic equivalent discomfort that is
     a. provoked by exertion or emotional stress and
     b. relieved by rest and/or nitroglycerin (17).
- ***Atypical* Angina (Probable):** Chest pain or discomfort with two characteristics of definite or typical angina (17).
- ***Nonanginal* Chest Pain:** Chest pain or discomfort that **meets one or none** of the typical angina characteristics (17).

Acute Coronary Syndrome: As defined by the ACC/AHA Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction, patients with an acute coronary syndrome include those whose clinical presentations cover the following range of diagnoses: unstable angina, MI without ST-elevation (NSTEMI), and myocardial infarction with ST-elevation (STEMI) (18).

Evaluating Perioperative Risk for Noncardiac Surgery

METHOD FOR DETERMINING PERIOPERATIVE RISK

Review Figure A1, "**Stepwise Approach to Perioperative Cardiac Assessment**," from the ACC/AHA 2009 Perioperative Guidelines (19). Based on the algorithm, once it is determined that the patient does not require urgent surgery, the clinician should determine the patient's active cardiac conditions and/or perioperative risk predictors—see definitions in the following text. If any active cardiac conditions (Table A1) and/or major risk predictors (Table A2) are present, Figure A1 suggests consideration of coronary angiography and postponing or canceling noncardiac surgery. Once perioperative risk predictors are assessed based on the algorithm, then the surgical risk and patient's functional status should be used to establish the need for noninvasive testing.

Table A1. Active Cardiac Conditions for Which the Patient Should Undergo Evaluation and Treatment Before Noncardiac Surgery (Class I, Level of Evidence: B)

Condition	Examples
Unstable coronary syndromes	Unstable or severe angina* (CCS class III or IV)†
	Recent MI‡
Decompensated HF (NYHA functional class IV; worsening or new-onset HF)	
Significant arrhythmias	High-grade atrioventricular block
	Mobitz II atrioventricular block
	Third-degree atrioventricular heart block
	Symptomatic ventricular arrhythmias
	Supraventricular arrhythmias (including atrial fibrillation) with uncontrolled ventricular rate (HR >100 bpm at rest)
	Symptomatic bradycardia
	Newly recognized ventricular tachycardia
Severe valvular disease	Severe aortic stenosis (mean pressure gradient >40 mm Hg, aortic valve area <1.0 cm^2, or symptomatic)
	Symptomatic mitral stenosis (progressive dyspnea on exertion, exertional presyncope, or HF)

*According to Campeau (20); †May include "stable" angina in patients who are unusually sedentary; ‡The American College of Cardiology National Database Library defines recent MI as >7 days but ≤1 month (within 30 days). Reprinted from Fleisher (19).

CCS indicates Canadian Cardiovascular Society; HF, heart failure; HR, heart rate; MI, myocardial infarction; and NYHA, New York Heart Association.

ECG—Uninterpretable: Refers to electrocardiograms with resting ST-segment depression (≥0.10 mV), complete left bundle-branch block, pre-excitation (Wolff-Parkinson-White syndrome), or paced rhythm.

Able to Exercise: Able to complete a diagnostic exercise treadmill examination.

Appendix B: Additional Methods

See the Methods section for a description of panel selection, indication development, scope of indications, and rating process.

Relationships With Industry and Other Entities

A list of all individuals participating in the development and review of this document and their institutional and/or

Table A2. Perioperative Clinical Risk Factors*

- History of ischemic heart disease
- History of compensated or prior heart failure
- History of cerebrovascular disease
- Diabetes mellitus (requiring insulin)
- Renal insufficiency (creatinine <2.0)

*As defined by the ACCF/AHA guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery (1). Note that these are not standard coronary artery disease risk factors.

organizational affiliations is presented in Appendix C. The ACCF and its partnering organizations rigorously avoid any actual, perceived, or potential conflicts of interest that might arise as a result of an outside relationship or personal interest of a member of the technical panel. Specifically, all panel members are asked to provide disclosure statements of all relationships that might be perceived as real or potential conflicts of interest. These statements were reviewed by the Appropriate Use Criteria Task Force, discussed with all members of the technical panel at the face-to-face meeting, and updated and reviewed as necessary. A table of disclosures by the technical panel and oversight task force members can be found in Appendix D.

Literature Review

The technical panel members were asked to refer to the relevant literature provided for each indication table when completing their ratings (Online Appendix at http://content.onlinejacc.org/cgi/content/full/j.jacc.2010.07.005/DC1).

Appendix C: ACCF/SCCT/ACR/AHA/ASE/ASNC/SCAI/SCMR 2010 Appropriate Use Criteria for Cardiac Computed Tomography Participants

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APPENDIX D. ACCF/SCCT/ACR/AHA/ASE/ASNC/SCAI/SCMR 2010 CARDIAC COMPUTED TOMOGRAPHY APPROPRIATE USE CRITERIA WRITING GROUP, TECHNICAL PANEL, TASK FORCE, AND INDICATION REVIEWERS—RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (IN ALPHABETICAL ORDER)

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ACCF/SCCT/ACR/AHA/ASE/ASNC/SCAI/SCMR 2010 Appropriate Use Criteria for Cardiac Computed Tomography

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