Appropriate Use Criteria

ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease

A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons

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Key Words: ACCF Appropriate Use Criteria, appropriateness criteria, imaging, ischemic heart disease, multimodality, SIHD.

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Abstract

The American College of Cardiology Foundation along with key specialty and subspecialty societies, conducted an appropriate use review of common clinical presentations for stable ischemic heart disease (SIHD) to consider use of stress testing and anatomic diagnostic procedures. This document reflects an updating of the prior Appropriate Use Criteria (AUC) published for radionuclide imaging (RNI), stress echocardiography (Echo), calcium scoring, coronary computed tomography angiography (CCTA), stress cardiac magnetic resonance (CMR), and invasive coronary angiography for SIHD. This is in keeping with the commitment to revise and refine the AUC on a frequent basis. A major innovation in this document is the rating of tests side by side for the same indication. The side-by-side rating removes any concerns about differences in indication or interpretation stemming from prior use of separate documents for each test. However, the ratings were explicitly not competitive rankings due to the limited availability of comparative evidence, patient variability, and range of capabilities available in any given local setting.

The indications for this review are limited to the detection and risk assessment of SIHD and were drawn from common applications or anticipated uses, as well as from current clinical practice guidelines. Eighty clinical scenarios were developed by a writing committee and scored by a separate rating panel on a scale of 1 to 9, to designate Appropriate, May Be Appropriate, or Rarely Appropriate use following a modified Delphi process following the recently updated AUC development methodology.

The use of some modalities of testing in the initial evaluation of patients with symptoms representing ischemic equivalents, newly diagnosed heart failure, arrhythmias, and syncope was generally found to be Appropriate or May Be Appropriate, except in cases where low pre-test probability or low risk limited the benefit of most testing except exercise electrocardiogram (ECG). Testing for the evaluation of new or worsening symptoms following a prior test or procedure was found to be Appropriate. In addition, testing was found to be Appropriate or May Be Appropriate for patients within 90 days of an abnormal or uncertain prior result. Pre-operative testing was rated Appropriate or May Be Appropriate only for patients who had poor functional capacity and were undergoing vascular or intermediate risk surgery with 1 or more clinical risk factors or an organ transplant. The exercise ECG was suggested as an Appropriate test for cardiac rehabilitation clearance or for exercise prescription purposes.

Testing in asymptomatic patients was generally found to be Rarely Appropriate, except for calcium scoring and exercise testing in intermediate and high-risk individuals and either stress or anatomic imaging in higher-risk individuals, which were all rated as May Be Appropriate. All modalities of follow-up testing after a prior test or percutaneous coronary intervention (PCI) within 2 years and within 5 years after coronary artery bypass graft (CABG) in the absence of new symptoms were rated Rarely Appropriate. Pre-operative testing for patients with good functional capacity, prior normal testing within 1 year, or prior to low-risk surgery also were found to be Rarely Appropriate. Imaging for an exercise prescription or prior to the initiation of cardiac rehabilitation was Rarely Appropriate except for cardiac rehabilitation clearance for heart failure patients.

Preface

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

Appropriate Use Criteria (AUC) publications reflect an ongoing effort by the ACCF to critically and systematically create, review, and categorize clinical situations where 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 procedures examined, evidence base, and clinical experience. 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 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 health care resources in cardiovascular imaging. The ultimate objective of AUC 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. AUC, thus, should not be considered substitutes for sound clinical judgment and practice experience.

We are grateful to the rating panel, a professional group with a wide range of skills and insights, for their thoughtful and thorough deliberation of the merits of cardiac testing for stable ischemic heart disease (SIHD). In addition to our thanks to the rating 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 Jenissa Haidari and Joseph Allen, who continually drove the process forward; and to the entire Task Force for their dedication, insight, and leadership.

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1. Introduction

Since the introduction of AUC in 2005, the ACCF has produced a number of documents that synthesize evidence for a specific cardiovascular procedure into appropriateness standards. The AUC were developed to support utilization of high-quality patterns of procedure use (i.e., appropriate use) while informing efforts to reduce resource use when benefits to patients are unlikely (1−3).

The range of tools used to evaluate cardiovascular disease has expanded over the past decade, especially in the field of noninvasive imaging. The purpose of this document is to delineate the appropriate use of various invasive and noninvasive testing modalities for the diagnosis and/or evaluation of SIHD across common patient presentations (indications), including:

1. Patients with signs and/or symptoms and/or various levels of risk for coronary disease (Section 1);
2. Patients with prior test results or coronary revascularization for follow-up evaluation (Section 2);
3. Patients scheduled for noncardiac surgery (Section 3);
4. Patients with an exercise prescription or referral to cardiac rehabilitation (Section 4).

2. Methods

The methods for development of AUC have evolved over time and were recently updated (2,3). A general overview of the methods is described in the following text.

The document is organized around the diagnostic and prognostic capabilities of anatomic and stress testing procedures to guide therapeutic choices for common clinical scenarios in the evaluation and follow-up of stable ischemic heart disease (SIHD). This document considers symptomatic and asymptomatic presentations for patients with and without a prior history of SIHD, coronary testing, or cardiac procedures. This approach more closely approximates the testing options available during an episode of care and therefore potentially offers a single AUC reference for cardiovascular specialists and referring physicians. Rather than attempting to determine a single best test for each indication, the goal of this document was to determine which testing modalities, if any, may or may not be reasonable for a specific indication.

Indication Development

The indications have been developed by a diverse writing committee composed of experts in both invasive and noninvasive diagnostic cardiac testing as well as general cardiology. Within each main indication category, a standardized approach has been used to capture the majority of clinical scenarios for which patients are referred for testing. Still, the writing committee recognizes that patient presentations vary widely and not all clinical factors are fully captured by these standardized scenarios. Indications were modified based on feedback from independent reviewers composed of both cardiovascular experts as well as those in general practice or in related specialty fields.

Rating Process and Scoring

Once the indications were finalized, a rating panel scored the indications independently. To ensure a diversity of expertise in the scoring process, the rating panel deliberately comprised individuals with a diversity of expertise, among which $<50\%$ regularly performed the particular procedures under evaluation. Wherever possible, indications have been mapped to relevant ACCF/AHA and subspecialty clinical practice guidelines and key publications/references (Online Appendix 1).

In scoring these criteria, the rating panel was asked to assess whether the use of the test for each indication is Appropriate, May Be Appropriate, or Rarely Appropriate, and was provided the following definition of appropriate use:

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 rating panel scored each indication as follows:

Median Score 7 to 9: Appropriate Care

An appropriate option for management of patients in this population because of benefits generally outweighing risks; effective option for individual care plans although not always necessary depending on physician judgment and patient-specific preferences (i.e., procedure is generally acceptable and is generally reasonable for the indication).

Median Score 4 to 6: May Be Appropriate Care

At times an appropriate option for management of patients in this population due to variable evidence or agreement regarding the benefit/risk ratio, potential benefit based on practice experience in the absence of evidence, and/or variability in the population; effectiveness for individual

* 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).

care must be determined by a patient's physician in consultation with the patient, based on additional clinical variables and judgment along with patient preferences (i.e., procedure may be acceptable and may be reasonable for the indication).

Median Score 1 to 3: Rarely Appropriate Care

Rarely an appropriate option for management of patients in this population due to the lack of a clear benefit/risk advantage; rarely an effective option for individual care plans; exceptions should have documentation of the clinical reasons for proceeding with this care option (i.e., procedure is not generally acceptable and is not generally reasonable for the indication).

After independent rating, 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. Panel members had the opportunity to suggest modifications to the indications based on the discussion. After the meeting, panel members were then asked to independently provide their final scores for each indication.

The level of agreement among panelists, as defined by RAND (4), was analyzed based on the BIOMED Concerted Action on Appropriateness rule for a panel of 14 to 16. As such, agreement was defined as an indication where 4 or fewer panelists' ratings fell outside the 3-point region containing the median score. Disagreement was defined as where at least 5 panelists' ratings fell in both the appropriate and the inappropriate categories. Any indication having disagreement was categorized as uncertain, regardless of the final median score. Indications that meet neither definition for agreement or disagreement are in a third, unlabeled, category.

3. Assumptions

To limit inconsistencies in interpretation, these specific assumptions should be considered when interpreting the ratings.

General Assumptions/Considerations

1. Each test is performed in compliance with published criteria for quality cardiac diagnostic testing as provided by national laboratory accreditation "standards" (i.e., Intersocietal Accreditation Commission, American College of Radiology) and societal "quality" guidelines documents, and interpreted by physicians who are qualified to do so.

   Stress echocardiography (echo) (5−7)

   Radionuclide myocardial perfusion imaging (MPI) (8−11)

   Cardiac magnetic resonance (CMR) (12−15)

   Coronary computed tomography angiography (CCTA) (16−19)

   Invasive coronary angiography (cath) (20,21)

   Radiation (22−24)

   Although geographic differences may exist in the availability or quality of the different modalities, raters were asked to make determinations based on published diagnostic and prognostic performance of the testing modalities. In other words, the rater should assume that each modality is locally available and performed on appropriate equipment, and is interpreted by individuals with acceptable training and expertise, when scoring each indication.
2. The clinical status of the patient should be assumed to be valid as stated in the indication (e.g., a thorough history and physical exam have occurred such that an asymptomatic patient is truly asymptomatic for the condition in question).
3. Evaluation of all indications is taking place under nonurgent circumstances.
4. All patients are receiving optimal standard care, including guideline-based risk factor modification for primary or secondary prevention of ischemic heart disease unless specifically noted.
5. In the event of an ambiguous angiogram, either intravascular ultrasound or fractional flow reserve may be performed as needed.
6. If the patient's characteristics are captured under more than 1 indication, the patient should be categorized according to the hierarchy provided in Figure 1.
7. Indications that describe routine or surveillance imaging imply that the test is being considered, not because of any change in clinical circumstances or any need to consider a change in therapy, but rather, solely because a period of time has elapsed.
8. For certain indications, emphasis has been placed upon the patient's ability to exercise and achieve 85% of their age-predicted maximal heart rate (220 − age). When the patient's ability to exercise is not explicitly stated, it should be assumed that the patient can exercise to a symptomatic endpoint or ≥85% of their age-predicted maximal heart rate. Similarly, it should be assumed that the electrocardiogram (ECG) is interpretable unless otherwise stated.
9. The mode of stress testing is assumed to be exercise (e.g., treadmill, bicycle) for patients able to exercise for the modalities for which some form of "stress" is required. For patients unable to exercise, it is assumed that pharmacological stress may be performed using the appropriate agent and/or with or without low level exercise. For CMR, it is assumed that vasodilator stress perfusion is the technique used.
10. Selection for and monitoring of contrast use is assumed to be in accord with published standards documents, when available (14,24).

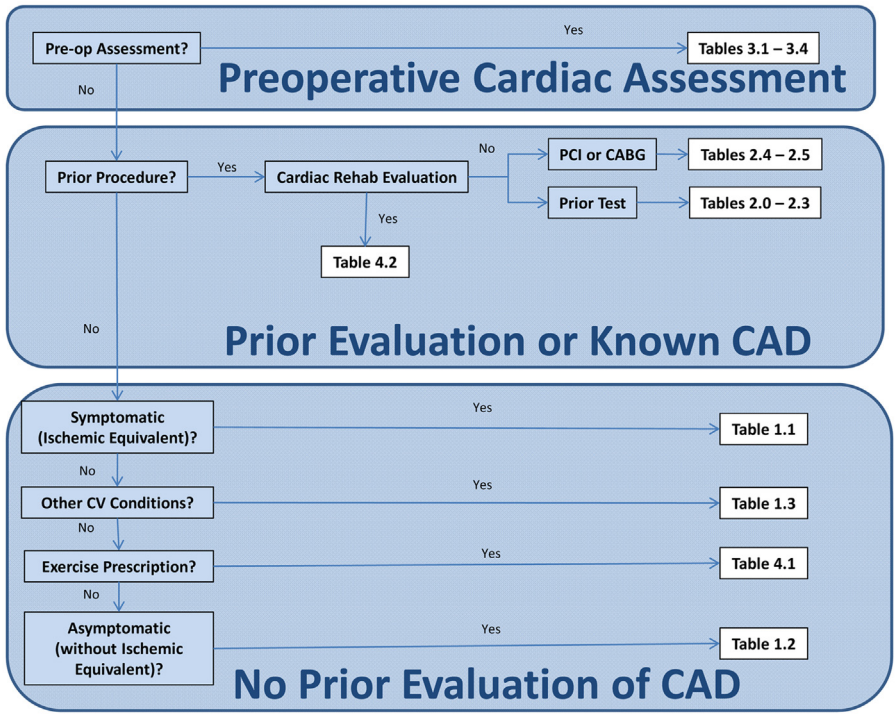

Fig. 1. Hierarchy of Potential Test Ordering Based on Clinical Presentation. For those patients who may be classified into more than 1 of the clinical indication tables and/or algorithms, this flowchart places clinical conditions into a hierarchy to aid in assessing appropriateness. Patients sent for testing for purposes of pre-operative cardiac assessment who are rated Rarely Appropriate for testing based on surgery alone may be considered for testing for other reasons (e.g., symptomatic). CABG = coronary artery bypass graft; CAD = coronary artery disease; CV = cardiovascular; PCI = percutaneous coronary intervention.

Multimodality-Specific Assumptions/Considerations

Comparative Rating.

11. Testing modalities are rated for their level of appropriateness specific to clinical scenarios, rather than a forced, rank order comparison against other testing modalities. The goal of this document is to identify any and all tests that are considered reasonable for a given clinical indication. Determination of the range of modalities that may or may not be reasonable for specific indications is the goal of this document, ***rather than determining a single best test for each indication or a rank order.*** As such, more than 1 test type or even all tests may be considered "Appropriate," "May Be Appropriate," or "Rarely Appropriate" for any given clinical indication.
12. If more than 1 modality falls into the same appropriate use category, it is assumed that physician judgment and available local expertise will be used to determine the correct test for an individual patient.
13. As with all previously published clinical policies, deviations by the rating panel from prior published documents were driven by new evidence and/or implementation knowledge that justifies such evolution. However, the reader is advised to pay careful attention to the wording of an indication in the present document when making comparisons to prior publications.
14. Indication ratings contained herein supersede the ratings of similar indications contained in previous AUC documents.

Risk/Benefit.

15. Overall, the patient presentation as described by each indication was used in the risk/benefit calculation. Each modality considered in this document has inherent risks that may include, but are not limited to: radiation exposure, contrast sensitivity, other bodily injury, and interpretation error. For any test, there may be certain patient populations that are more susceptible to known risks of a test type that are not specifically captured in the indications, but that deserve consideration when rating. Such risks should be viewed "on balance" and not used as justification to systematically reduce the level of appropriateness of a particular test compared with other tests (e.g., tests that impart ionizing radiation should not necessarily receive a lower score than tests that do not). Thus, a given modality should be weighed specifically in the context of the clinical scenario, with the potential risks considered relative to the potential benefit gained.

Contraindications.

16. Unless explicitly stated, it should be assumed that patients presenting for a specific clinical indication are potential candidates for all of the test types to be rated, and do not present with strong contraindications that preclude them from being tested (e.g., renal dysfunction, presence of an implanted device, etc.).

Radiation Safety.

17. Specific evidence relating to an increased cancer risk due to radiation exposure following the commonly applied cardiovascular (CV) imaging modalities has not been systematically reported, although many experts in the field of radiation biology and epidemiology support a linear no-threshold hypothesis whereby any exposure is related to a long-term projected risk of cancer (22,23).
18. The following radiation safety concepts are being applied for each scenario (25):
    A. Clinical benefit should be As High As Reasonably Achievable (AHARA). AHARA should be used for the identification of patients for whom the use of CV imaging results in higher overall clinical benefit. Adherence to AHARA embraces the guiding principle that testing should be geared toward at-risk cohorts that are most likely to experience a net benefit from testing, as defined by a clinical indication.
    B. Radiation exposure should be As Low As Reasonably Achievable (ALARA). ALARA should be used to guide both test choice and test protocols emphasizing dose-reduction techniques while preserving diagnostic image quality. Implicit in the principle of ALARA is the limitation of radiation exposure from CV imaging within vulnerable populations such as younger patients, in whom the projected cancer risk arising from radiation exposure may be higher than for older patients.
19. For each clinical scenario, tests that impart ionizing radiation will be performed by labs that have adopted contemporary dose-reduction techniques (24). Based on the available evidence, optimized dose-reduction strategies may be employed in large segments of the adult population and should be widely utilized.

Cost/Value.

20. The differential costs between modalities have narrowed in recent years and vary depending on payer and site of service, thus making the relevance of baseline cost to test selection less germane (Online Appendix 2). As such, expectations of lower procedural costs should not be reflexively favored.
21. Clinical benefits should always be considered first, and costs should be considered in relationship to these benefits in order to better convey net value. For example, a procedure with moderate clinical efficacy for a given AUC indication should not be scored as more appropriate than a procedure with high clinical efficacy solely due to its lower cost. When available, scientific evidence exists to support clinical benefit, cost efficiency, and cost effectiveness should be considered for any indication. In addition to net health benefits versus risks, value may be informed by multiple measures of potential economic impact, such as:
    - Induced downstream or layered testing rates (e.g., angiography);
    - Comparative cost savings or minimization for diagnosis or near-term follow-up;
    - Cost to reduce adverse outcomes (e.g., cost per hospitalization averted);
    - Cost per life-year gained;
    - For cardiac tests, patterns of downstream costs or potential cost savings for any given indication—modality pairing should be considered implicitly.

Evidence Review.

Availability of Evidence.

22. Whenever possible, clinical indications were rated in relation to available data derived from randomized trials and observational registries. When these data do not exist, other published scientific evidence was considered. For many indications, a simple review of the number of patients studied, study design, origin of sponsorship, and questions answered was insufficient to determine accuracy.

Time Biases in Available Data.

23. Newer technologies should not be considered necessarily more or less appropriate compared with older technologies. Apparent differences in diagnostic accuracy and risk stratification between older and newer techniques may not be "real," especially when not directly compared and when historical data are utilized. As treatment paradigms evolve, with diagnosis often occurring at earlier stages of disease, the comparison of diagnostic modalities, often used at different stages of the disease process, poses unique challenges. Furthermore, as treatments evolve and result in more effective risk reduction, detecting meaningful outcome differences is more difficult for newer technologies or in contemporary comparative analyses. Conversely, older literature supporting a given indication for an established modality should not be disregarded or perceived as irrelevant to today's clinical testing practices. In addition, older studies may fail to reflect technological advances in a specific modality or the application of a particular method to a refined patient-refined group.

4. Definitions

Definitions of terms used throughout the indication set are listed here.

Definitions for All Sections

Symptomatic (includes potentially ischemic equivalents as relevant): Chest Pain Syndrome or Anginal Equivalent

Patients may present with any constellation of clinical findings that the physician feels is consistent with coronary artery disease (CAD). Examples of such findings include, but are not limited to, chest pain, chest tightness, chest burning, epigastric pain, shoulder pain, jaw pain, or other symptoms/findings suggestive of CAD. Non-chest pain symptoms (e.g., dyspnea or reduced/worsening effort tolerance) or signs (e.g., new electrocardiographic abnormalities) that are thought to be consistent with CAD may also be considered to be an ischemic equivalent. Symptomatic patients described in the tables with certain pre-test probabilities are assumed to present only with the relevant symptomatology (e.g., low pre-test probability patients may present with atypical or nonanginal chest pain, but not typical chest pain or tightness).

Indication

A set of patient-specific conditions defines an indication. The term *clinical indication* does not necessarily mean that any test is warranted. In other words, for some clinical indications, all modalities may be rated as Rarely Appropriate.

Unable to Exercise

Patient inability to exercise is assumed to be due to noncardiovascular issues such as arthritis and not cardiovascular issues that would inherently increase a patient's risk.

Definitions for Section 1

ECG: Uninterpretable

This refers to ECGs with resting abnormalities such as ST-segment depression (≥0.10 mV), complete left bundle branch block, pre-excitation (Wolff-Parkinson-White syndrome), digoxin use, or ventricular paced rhythm that would make the exercise ECG difficult to interpret.

Definitions for Section 1: Table 1.1

Pre-Test Probability of CAD: Symptomatic (Ischemic Equivalent) Patients

When symptoms are present, and there is sufficient suspicion of heart disease to warrant cardiac evaluation, the clinician should make a probability estimate of the likelihood of CAD prior to selecting testing. There are a number of validated risk assessment models (26,27) available that can be used to calculate this probability. Clinicians should be familiar with those algorithms that pertain to the populations they encounter most often. In scoring the indications, the following probabilities, as calculated from any of the various available validated algorithms, should be applied.

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

The method recommended by the ACCF/AHA Guidelines for Stable Ischemic Heart Disease (28) is provided as 1 example of a method used to calculate pre-test probability and is a modification of a previously published literature review (29). Please refer to Table A and the definition of angina characteristics. It is important to note that other factors or ECG findings (e.g., prior infarction) can affect pre-test probability, although these factors are not accounted for in Table A. Similarly, although not incorporated into the algorithm, other CAD risk factors may also affect pre-test likelihood of CAD. Detailed nomograms are available that incorporate the effects of a history of prior infarction, ECG Q waves, and ST- and T-wave changes, diabetes, and other cardiac risk factors (30). Patients with multiple established coronary risk factors not accounted for in Table A are likely not to have < 10% likelihood of coronary artery disease and may require reclassification.

Table A. Diamond and Forrester Pre-Test Probability of Coronary Artery Disease by Age, Sex, and Symptoms*

Age (years)	Sex	Typical/Definite Angina Pectoris	Atypical/Probable Angina Pectoris	Nonanginal Chest Pain
≤39	Men	Intermediate	Intermediate	Low
	Women	Intermediate	Very low	Very low
40–49	Men	High	Intermediate	Intermediate
	Women	Intermediate	Low	Very low
50–59	Men	High	Intermediate	Intermediate
	Women	Intermediate	Intermediate	Low
≥60	Men	High	Intermediate	Intermediate
	Women	High	Intermediate	Intermediate

High: >90% pre-test probability. **Intermediate:** between 10% and 90% pre-test probability. **Low:** between 5% and 10% pre-test probability. **Very low:** <5% pre-test probability.

*Modified from the ACC/AHA 2002 Guideline Update for Exercise Testing (30a).

Angina

- ***Typical* Angina (Definite):** Defined as 1) substernal chest pain or discomfort that is 2) provoked by exertion or emotional stress and 3) relieved by rest and/or nitroglycerin (31).
- ***Atypical* Angina (Probable):** Chest pain or discomfort that **lacks one** of the characteristics of definite or typical angina.
- ***Nonanginal* Chest Pain:** Chest pain or discomfort that **meets one or none** of the typical angina characteristics.

Definitions for Section 1: Table 1.2 and Section 2: Table 2.2

Global CAD Risk

It is assumed that clinicians will use current standard methods of global risk assessment such as those presented in the National Heart, Lung, and Blood Institute report on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III [ATP III]) (32), PROCAM (33), or similar national guidelines.

- When applying a global risk score for asymptomatic patients, risk is defined as the probability of experiencing a CAD event over a given time period. The ATP III report specifies CAD event risk over the next 10 years among asymptomatic individuals. CAD risk refers to 10-year risk for myocardial infarction or CAD death. However, acknowledging that global risk scores may be miscalibrated in certain populations (e.g., women, younger men), clinical judgment may be used to document an exception to the AUC. Moreover, important clinical risk factors, such as family history of premature CAD, though not included in global risk scoring, also may be influential considerations in clinical judgment.
- **Low global CAD risk**

  Defined by an age-specific risk level that is below average. In general, low risk will correlate with a 10-year absolute CAD risk $<10\%$. However, in women and younger men, low risk may correlate with 10-year absolute CAD risk $<6\%$.
- **Intermediate global CAD risk**

  Intermediate risk is defined as a 10-year CAD risk from 10% to 20%. Among women and younger men, an expanded intermediate-risk range of 6% to 20% may be appropriate.
- **High global CAD risk**

  High risk is defined as a 10-year CAD risk of $>20\%$. CAD equivalents (e.g., diabetes mellitus, peripheral arterial disease) can also define high risk.

Definitions for Section 1: Table 1.3

Heart Failure

Refer to stages B, C, and D heart failure as defined by the ACCF/AHA Guideline for the Management of Heart Failure (33a).

Ventricular Tachycardia

A cardiac arrhythmia of 3 or more consecutive complexes in duration that emanates from the ventricles at a rate of >100 beats/min (cycle length $<$ 600 ms).

Sustained Ventricular Tachycardia

Ventricular tachycardia (VT) that is >30 seconds in duration and/or requires termination due to hemodynamic compromise in <30 seconds (34,35).

Nonsustained VT

Three or more consecutive beats of VT that self-terminate in <30 seconds.

Frequent Premature Ventricular Contractions

More than 30 premature ventricular contractions (PVCs) per hour (36).

Syncope

Transient loss of consciousness due to global cerebral hypoperfusion characterized by rapid onset, short duration, and spontaneous complete recovery (37), not lightheadedness or dizziness alone.

Definitions for Section 2: All Tables

Nonobstructive Invasive Coronary Angiogram

Less than 50% luminal diameter narrowing, by visual assessment, of an epicardial or left main stenosis measured in the ''worst view'' angiographic projection.

Definitions for Section 3: All Tables

Evaluating Perioperative Risk for Noncardiac Surgery

Method for Determining Perioperative Risk. See Figure 2, ''Stepwise Approach to Perioperative Cardiac Assessment,'' from the ACCF/AHA 2009 perioperative guidelines (38). On the basis of the algorithm, once it is determined that the patient does not require urgent surgery, the clinician should determine the patient's active cardiac conditions (see Table B) and/or perioperative risk predictors (see Table C). If any active cardiac conditions and/or major risk predictors are present, Figure 2 suggests a directed workup of the underlying condition, 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.

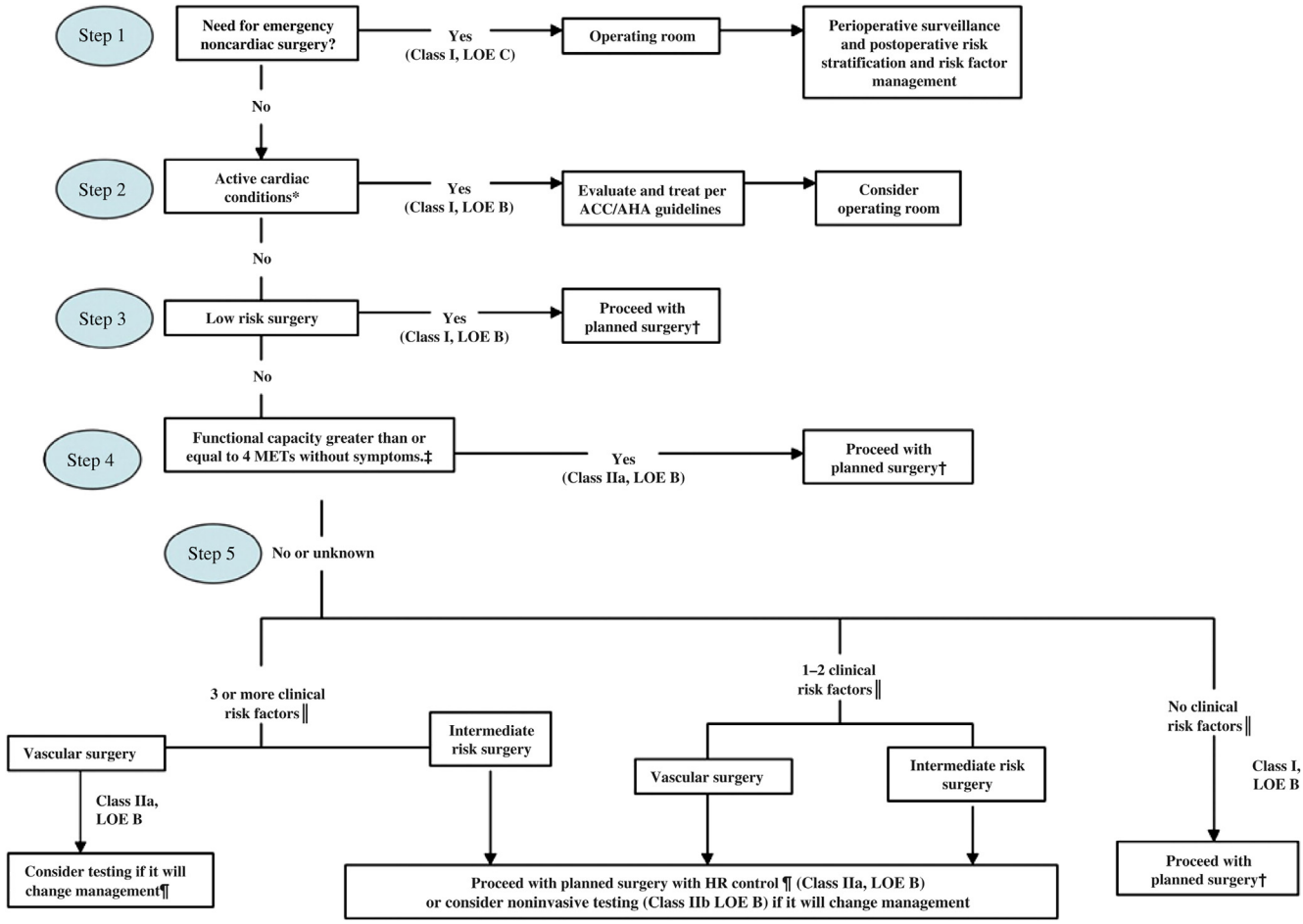

Fig. 2. Stepwise Approach to Perioperative Cardiac Assessment. Cardiac evaluation and care algorithm for noncardiac surgery based on active clinical conditions, known cardiovascular disease, or cardiac risk factors for patients ≥50 years of age. ACC = American College of Cardiology; AHA = American Heart Association; HR = heart rate; LOE = level of evidence; MET = metabolic equivalent. Modified from Fleisher et al. (38).

Table B. Active Cardiac Conditions for Which the Patient Should Undergo Evaluation and Treatment Before Non-Emergent 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 beats/min 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)

CCS = Canadian Cardiovascular Society; HF = heart failure; HR = heart rate; MI = myocardial infarction; NYHA = New York Heart Association.
*According to Campeau (39);
†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 et al. (38).

Table C. Perioperative Clinical Risk Factors*

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

ACCF = American College of Cardiology Foundation; AHA = American Heart Association.

*As defined by the ACCF/AHA Guidelines on Perioperative Cardiovascular Evaluation and Care For Noncardiac Surgery. Note that these are not standard coronary artery disease risk factors. Reprinted from Fleisher et al. (38).

5. Abbreviations

AUC = Appropriate Use Criteria
CABG = coronary artery bypass graft
CAD = coronary artery disease
CHD = coronary heart disease
CMR = cardiac magnetic resonance
CCTA = coronary computed tomography angiography
ECG = electrocardiogram
ECHO = echocardiogram
METS = metabolic equivalents
PCI = percutaneous coronary intervention
PVC = premature ventricular contraction
RNI = radionuclide imaging
SIHD = stable ischemic heart disease
VT = ventricular tachycardia

6. Results of Ratings

The final ratings for Multimodality AUC on the Detection and Risk Assessment of SIHD are listed by indication in Tables 1.1, 1.2, 1.3, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 3.1, 3.2, 3.3, 4.1, and 4.2. The final score reflects the median score of the 17 rating panel members and has been labeled according to the categories of Appropriate (median 7 to 9), May Be Appropriate (median 4 to 6), and Rarely Appropriate (median 1 to 3) (Online Appendix 3). Eighteen of the 80 indications were considered Rarely Appropriate across all modalities whereas the remainder were of mixed appropriateness. The discussion section highlights further general trends in the scoring related to specific patient populations.

7. Multimodality for the Detection and Risk Assessment of Ischemic Heart Disease Appropriate Use Criteria (by Indication)

Section 1. Detection of CAD/Risk Assessment

Table 1.1. Symptomatic

Refer to pages 16 and 17 for relevant definitions, in particular Table A and text for age, sex, symptom presentation, and risk factors relevant to each pre-test probability category

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
1.	• Low pre-test probability of CAD • ECG interpretable AND able to exercise	A	R	M	R	R	R	R
2.	• Low pre-test probability of CAD • ECG uninterpretable OR unable to exercise		A	A	M	R	M	R
3.	• Intermediate pre-test probability of CAD • ECG interpretable AND able to exercise	A	A	A	M	R	M	R
4.	• Intermediate pre-test probability of CAD • ECG uninterpretable OR unable to exercise		A	A	A	R	A	M
5.	• High pre-test probability of CAD ECG interpretable AND able to exercise	M	A	A	A	R	M	A
6.	• High pre-test probability of CAD • ECG uninterpretable OR unable to exercise		A	A	A	R	M	A

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CAD = coronary artery disease; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 1.2. Asymptomatic (Without Symptoms or Ischemic Equivalent)

Refer to pages 17 and 18 for relevant definitions

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
7.	• Low global CHD risk • Regardless of ECG interpretability and ability to exercise	R	R	R	R	R	R	R
8.	• Intermediate global CHD risk • ECG interpretable and able to exercise	M	R	R	R	M	R	R
9.	• Intermediate global CHD risk ECG uninterpretable OR unable to exercise		M	M	R	M	R	R
10.	• High global CAD Risk • ECG interpretable and able to exercise	A	M	M	M	M	M	R
11.	• High global CAD Risk • ECG uninterpretable OR unable to exercise		M	M	M	M	M	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CAD = coronary artery disease; CCTA = coronary computed tomography angiography; CHD = coronary heart disease; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 1.3. Other Cardiovascular Conditions

Refer to pages 18 and 19 for relevant definitions

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
Newly Diagnosed Heart Failure (Resting LV Function Previously Assessed but No Prior CAD Evaluation)								
12.	• Newly diagnosed systolic heart failure	M	A	A	A	R	A	A
13.	• Newly diagnosed diastolic heart failure	M	A	A	A	R	M	M
Evaluation of Arrhythmias Without Ischemic Equivalent (No Prior Cardiac Evaluation)								
14.	• Sustained VT	A	A	A	A	R	M	A
15.	• Ventricular Fibrillation	M	A	A	A	R	M	A
16.	• Exercise induced VT or nonsustained VT	A	A	A	A	R	M	A
17.	• Frequent PVCs	A	A	A	M	R	M	M
18.	• Infrequent PVCs	M	M	M	R	R	R	R
19.	• New-onset atrial fibrillation	M	M	M	R	R	R	R
20.	• Prior to initiation of anti-arrhythmia therapy in high global CAD risk patients	A	A	A	A	R	M	R
Syncope Without Ischemic Equivalent								
21.	• Low global CAD Risk	M	M	M	R	R	R	R
22.	• Intermediate or High Global CAD Risk	A	A	A	M	R	M	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CAD = coronary artery disease; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; LV = left ventricular; M = May Be Appropriate; PVC = premature ventricular contraction; R = Rarely Appropriate; RNI = radionuclide imaging; VT = ventricular tachycardia.

Section 2. Prior Testing or Procedure

Section 2.1. Prior Testing Without Intervening Revascularization (If Intervening Revascularization Since Most Recent Test, Refer to Section 2.2).

Table 2.0. Sequential Testing (≤90 Days): Abnormal Prior (Test/Study)

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
23.	• Abnormal rest ECG findings (potentially ischemic in nature such as LBBB, T-wave inversions) • Low global CAD risk		A	A	M	R	M	R
24.	• Abnormal rest ECG findings (potentially ischemic in nature such as LBBB, T-wave inversions) • Intermediate to high global CAD risk		A	A	A	R	M	M
25.	• Abnormal prior exercise ECG test		A	A	A	R	A	A
26.	• Abnormal prior stress imaging study (assumes not repeat of same type of stress imaging)	R	M	M	M	R	A	A
27.	• Obstructive CAD on prior CCTA study	M	A	A	A			A
28.	• Obstructive CAD on prior invasive coronary angiography	M	A	A	A	R	R	
29.	• Abnormal prior CCT calcium (Agatston Score >100)	A	A	A	M		M	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CAD = coronary artery disease; CCT = coronary computed tomography; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; LBBB = left bundle branch block; M = May Be Appropriate; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 2.1. Sequential or Follow-Up Testing (≤90 Days): Uncertain Prior Results

	Indication text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
Equivocal, Borderline, or Discordant Prior Noninvasive Evaluation Where Obstructive CAD Remains a Concern								
30.	• Prior exercise ECG test		A	A	A	R	A	M
31.	• Prior stress imaging study (assumes not repeat of same type of stress imaging)	R	M	M	M	R	A	A
32.	• Prior CCTA	M	A	A	A			A
Prior Coronary Angiography (Invasive or Noninvasive)								
33.	• Coronary stenosis or anatomic abnormality of unclear significance found on cardiac CCTA	M	A	A	A			A
34.	• Coronary stenosis or anatomic abnormality of unclear significance on previous coronary angiography	M	A	A	A	R	R	

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 2.2. Follow-Up Testing (>90 Days): Asymptomatic or Stable Symptoms

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
Abnormal Prior Exercise ECG Test								
Asymptomatic or Stable Symptoms								
35.	• Last test <2 years ago	R	R	R	R	R	R	R
36.	• Last test ≥2 years ago	M	M	M	R	R	R	R
Abnormal Prior Stress Imaging Study								
Asymptomatic or Stable Symptoms								
37.	• Last study <2 years ago	R	R	R	R	R	R	R
38.	• Last study ≥2 years ago	R	M	M	M	R	R	R
Obstructive CAD on Prior Coronary Angiography (Invasive or Noninvasive)								
Asymptomatic (Without Ischemic Equivalent) or Stable Symptoms								
39.	• Last study <2 years ago	R	R	R	R	R	R	R
40.	• Last study ≥2 years ago	M	M	M	M	R	R	R
Prior Coronary Calcium Agatston Score								
Asymptomatic (Without Ischemic Equivalent) or Stable Symptoms								
41.	• Agatston score <100	R	R	R	R	R	R	R
42.	• Low to intermediate global CAD risk Agatston score between 100 and 400	M	M	M	R	R	R	R
43.	• High global CAD risk Agatston score between 100 and 400	M	M	M	M	R	R	R
44.	• Agatston score >400	A	M	M	M	R	R	R
Normal Prior Exercise ECG Test								
Asymptomatic (Without Ischemic Equivalent)								
45.	• Low global CAD risk	R	R	R	R	R	R	R
46.	• Intermediate to high global CAD risk • Test <2 years ago	R	R	R	R	R	R	R
47.	• Intermediate to high global CAD risk • Test ≥2 years ago	M	M	M	M	R	R	R
Normal Prior Stress Imaging Study OR Nonobstructive CAD on Angiogram (Invasive or Noninvasive)								
Asymptomatic (Without Ischemic Equivalent)								
48.	• Low global CAD risk	R	R	R	R	R	R	R
49.	• Intermediate to high global CAD risk • Study <2 years ago	R	R	R	R	R	R	R
50.	• Intermediate to high global CAD risk • Study ≥2 years ago	M	M	M	M	R	R	R
Normal Prior Exercise ECG Test								
Stable Symptoms								
51.	• Low global CAD risk	R	R	R	R	R	R	R
52.	• Intermediate to high global CAD risk • Test <2 years ago	R	R	R	R	R	R	R
53.	• Intermediate to high global CAD risk • Test ≥2 years ago	M	M	M	M	R	R	R
Normal Prior Stress Imaging Study OR Nonobstructive CAD on Angiogram (Invasive or Noninvasive)								
Stable Symptoms								
54.	• Low global CAD risk	R	R	R	R	R	R	R
55.	• Intermediate to high global CAD risk • Study <2 years ago	R	R	R	R	R	R	R
56.	• Intermediate to high global CAD risk • Study ≥2 years ago	M	M	M	M	R	R	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CAD = coronary artery disease; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 2.3. Follow-Up Testing: New or Worsening Symptoms

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
57.	• Normal exercise ECG test	M	A	A	A	R	A	M
58.	• Nonobstructive CAD on coronary angiography (invasive or noninvasive) OR normal prior stress imaging study	M	A	A	A	R	R	M
59.	• Abnormal exercise ECG test	R	A	A	A	R	A	A
60.	• Abnormal prior stress imaging study	R	M	M	M	R	A	A
61.	• Obstructive CAD on CCTA study	M	A	A	A	R	R	A
62.	• Obstructive CAD on invasive coronary angiography	A	A	A	M	R	R	A
63.	• Abnormal CCTA calcium (Agatston Score >100)	A	A	A	A	R	M	A

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CAD = coronary artery disease; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; R = Rarely Appropriate; RNI = radionuclide imaging.

Section 2.2. Post-Revascularization (PCI or CABG)

Table 2.4. Symptomatic (Ischemic Equivalent)

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
64.	• Evaluation of ischemic equivalent	M	A	A	A	R	M	A

A = Appropriate; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 2.5. Asymptomatic (Without Ischemic Equivalent)

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
65.	• Incomplete revascularization • Additional revascularization feasible	M	A	A	M	R	R	R
66.	• Prior left main coronary stent	M	M	M	M	R	M	M
67.	• <5 years after CABG	R	R	R	R	R	R	R
68.	• ≥5 years after CABG	M	M	M	M	R	R	R
69.	• <2 years after PCI	R	R	R	R	R	R	R
70.	• ≥2 years after PCI	M	M	M	M	R	R	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CABG = coronary artery bypass graft; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; PCI = percutaneous coronary intervention; R = Rarely Appropriate; RNI = radionuclide imaging.

Section 3. Pre-Operative Evaluation for Noncardiac Surgery

Table 3.1. Moderate-to-Good Functional Capacity (≥4 METs) OR No Clinical Risk Factors

Refer to pages 12 and 13 for relevant definitions

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
71.	• Any surgery	R	R	R	R	R	R	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 3.2. Asymptomatic AND < 1 Year Post Any of the Following: Normal CT or Invasive Angiogram, Normal Stress Test for CAD, or Revascularization

Refer to pages 12 and 13 for relevant definitions

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
72.	• Any surgery	R	R	R	R	R	R	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 3.3. Poor or Unknown Functional Capacity (<4 METs)

Refer to pages 12 and 13 for relevant definitions

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
73.	• Low-risk surgery • ≥1 clinical risk factor	R	R	R	R	R	R	R
74.	• Intermediate-risk surgery • ≥1 clinical risk factor	M	M	M	M	R	R	R
75.	• Vascular surgery • ≥1 clinical risk factor	M	A	A	M	R	R	R
76.	• Kidney transplant	M	A	A	M	R	R	M
77.	• Liver transplant	M	A	A	M	R	R	M

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; R = Rarely Appropriate; RNI = radionuclide imaging.

Section 4. Determine Exercise Level Prior to Initiation of Exercise Prescription or Cardiac Rehabilitation

Table 4.1. Exercise Prescription

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Diagnostic Coronary Angiography
78.	• No prior revascularization	A	R	R	R	R	R	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CAD = coronary artery disease; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 4.2. Prior to the Initiation of Cardiac Rehabilitation (As a Stand-Alone Indication): Able to Exercise

	Indication Text	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Diagnostic Coronary Angiography
79.	• Post revascularization (PCI or CABG)	A	R	R	R	R	R	R
80.	• Heart failure	A	M	M	M	R	R	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

A = Appropriate; CABG = coronary artery bypass graft; CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; M = May Be Appropriate; PCI = percutaneous coronary intervention; R = Rarely Appropriate; RNI = radionuclide imaging.

8. Discussion

The current paper represents considerable progress in the development and evolution of the depth and extensiveness of AUC documents on cardiovascular imaging procedures. Initial AUC publications on indications for imaging in the detection and risk assessment of SIHD were centered around individual procedures. In the current document, we present a synthesis of evidence and clinical experience for all commonly employed noninvasive and invasive procedures for diagnosis of CAD. Importantly, this is the first imaging AUC document that now integrates the rating of variety of procedures ranging from the exercise ECG to the diagnostic coronary angiogram, representing the array of choices available to the medical community. In fact, the exercise ECG is a commonly employed diagnostic procedure that has not been represented in prior documents and is now included in the current report. Given the paucity of comparative effectiveness data, the evidence base is insufficient for cross-indication comparisons between modalities and, thus, determining a single best procedure is not possible. We believe that this evidence synthesis, representing decades of published reports, will foster a greater knowledge base on the part of the referring physician to promote optimized decision making within the diagnostic evaluation of SIHD. This approach to current and future AUC documents represents an effort to produce a single AUC document on effective procedural choices for a given

clinical strategy rather than procedure specific AUC documents.

Clinical Scenarios

The clinical scenarios represented in the document cover a range of typical patient presentations, which represent a range of appropriateness for each procedure. The use of several modalities of testing in the initial evaluation of patients with symptoms representing SIHD or ischemic equivalents (i.e., newly diagnosed heart failure, arrhythmias, or syncope) was generally found to be Appropriate or May Be Appropriate, except in cases where low pre-test probability or low risk limited the benefit of most testing except exercise ECG. Testing for the evaluation of new or worsening symptoms following a prior test or procedure was also found to be Appropriate. In addition, testing was found to be Appropriate or May Be Appropriate for patients within 90 days of an abnormal or uncertain prior test result. Pre-operative testing was rated Appropriate or May Be Appropriate only for patients who had poor functional capacity and were undergoing intermediate or vascular surgery with 1 or more clinical risk factors or prior to an organ transplant. Exercise ECG was rated as an Appropriate test for cardiac rehabilitation clearance or for exercise prescription purposes.

By comparison to symptomatic patients, testing in asymptomatic patients was generally found to be Rarely Appropriate, except for calcium scoring and exercise testing in intermediate- and high-risk individuals and either stress or anatomic imaging in higher-risk individuals, which were all rated as May Be Appropriate. All modalities of follow-up testing after a prior test or PCI within 2 years or within 5 years after CABG in the absence of new symptoms were rated Rarely Appropriate. Pre-operative testing for patients with good functional capacity, prior normal testing within 1 year, or those undergoing low-risk surgery also was found to be Rarely Appropriate. Imaging for an exercise prescription or prior to the initiation of cardiac rehabilitation was Rarely Appropriate except for cardiac rehabilitation clearance for heart failure patients.

Rating Changes From Prior Documents

This document supersedes prior AUC documents that cover the same or similar clinical scenarios for individual procedures (e.g., for the various stress imaging modalities and anatomic procedures) (40–43).

Thirty-seven of the indications were rated differently in the current document than they were rated in the prior relevant documents (Online Appendix 4). Of these divergences, 18 could be reasonably expected by virtue of the fact that modalities were rated in tandem by 1 panel. The current document incorporated slight wording changes within the definitions and/or the indications sections relative to previous documents in order to remove inconsistencies. Other rating differences may be attributed to the changing practice environment and evolution in cumulative clinical experience with these procedures, and maturation of the field since the original documents' publication. For instance, in this document, ratings for stress CMR were more often in accord with the ratings for stress RNI, stress echo, and exercise treadmill testing. This may reflect the simultaneous rating of modalities and the growing body of evidence supporting the utility and accuracy of stress CMR (44–49). Of the remaining 19 divergent ratings, all but 1, in stress echo, were for CCTA, coronary calcium scoring, and invasive coronary angiography.

Six ratings were lower than previous documents, and all were among asymptomatic patients. Despite supporting evidence, these lower ratings for asymptomatic patients may reflect concern, voiced by many physicians, that the previous Appropriate Use ratings could have been misinterpreted as a recommendation to use these tests to screen a broad swath of the U.S. population. Although the general ratings are lower in the current document relative to prior documents, both coronary artery calcium and exercise ECG were rated as May Be Appropriate for asymptomatic patients of intermediate global risk. As such, 1 of these tests can be an option for further evaluation of potential SIHD in an individual patient when deemed reasonable by the patient's physician. For instance, prior clinical practice guidelines have supported the role of coronary artery calcium with a Class IIa, Level of Evidence B recommendation for identifying at-risk individuals who may qualify for risk detection and targeted prevention efforts including altered medical therapeutic regiments and/or lifestyle modifications.

For CCTA, there were 7 additional differences, 4 of which recognized the value of CCTA in sequential or follow-up testing. The improved rating of CCTA following an abnormal stress imaging study may reflect the evolution of the evidence base since prior ratings (50–52). Notably, there were also a few indications where the ratings of CCTA decreased, specifically for symptomatic patients or in the pre-operative setting, ratings that are consistent with the perioperative guidelines and recent SIHD guidelines (28,38).

Another important difference from prior documents is the May Be Appropriate rating for stress echo among symptomatic patients with low pre-test probability and an ability to exercise and an interpretable ECG, a presentation also reviewed in the recent SIHD guideline (28). However, stress echo was less strongly supported for this scenario than exercise treadmill testing. In fact, although not a rating choice, "no testing at all" may also be considered an option in such low-risk cases since the low pre-test probability alone limits the value of a positive test in determining likelihood of disease and often could then potentially lead to further testing. This is in keeping with the concept that because a test was rated Appropriate or May Be Appropriate, this does not indicate that a test must be performed. If testing is considered, several studies and an expert consensus statement have reviewed the utility of exercise treadmill testing in this population, which is largely

composed of women <60 years old with atypical and nonanginal presentations based on pre-test probability calculations (53,54). An ECG treadmill test can serve as an effective initial test and significantly reduce the number of patients who proceed to further stress imaging or other testing (53). Despite the fact that ST-segment depression and the ECG reading portion of the test have been shown to be less reliable in women, the ability to integrate multiple parameters (exercise capacity, chronotropic response, heart rate response, blood pressure response, and Duke Treadmill Score) from an exercise ECG can provide physicians with the necessary diagnostic accuracy, especially given the excellent negative predictive value of the test (55).

Interpretation, Assumptions, and Future Directions

There are a number of important considerations in interpreting and applying the standards contained in this document.

These new AUC are intended to provide guidance for patients and clinicians when it comes to making a reasonable testing choice amongst the available testing modalities for SIHD detection or risk assessment. Although the various modality ratings for each indication are presented together, the ratings are not intended to be comparative or indicate a ''best test'' for a given indication. Rather, each rating should be interpreted as a summary of the available evidence supplemented by expert opinion for an individual stress test or anatomic procedure. For example, just because 2 stress imaging modalities are rated as Appropriate and the third as May Be Appropriate, it may still be reasonable to choose the third modality for a particular patient due to his/her individual characteristics. In performing the ratings, the technical panel was instructed not to compare modalities with one another for any given indication. Rather, each test was to be rated individually for each scenario based upon the quality of the published evidence as well as the expert opinion of the rating panel. In the absence of robust comparative effectiveness evidence, a comparative rating approach would be both premature and misleading. Thus, although these ratings reflect the existing evidence base supplemented by expert consensus, there is no doubt that more research is needed to further identify, not only when to use any given modality, but also when to favor one over another. Importantly, there are a number of ongoing large randomized trials that may provide sufficient evidence to allow for comparative ratings in future documents (56,57).

The contributors also acknowledge that the division of these scores into 3 rating categories of appropriate use is often somewhat arbitrary and that the category designations should be viewed instead as a continuum. At the same time, the AUC process is intended to be transparent for users. Accordingly, the technical panel's numerical scores may be found online, Appendix 3. However, the categorical ratings only, which are shown in the tables in the preceding text, are intended for clinical use. The contributors also recognize diversity in clinical opinion for particular clinical scenarios. As such, the criteria can inform procedure use, but physician judgment is required for individual patient decisions. Furthermore, the clinical scenario list is intended to be relatively comprehensive, without being exhaustive. Accordingly, some patients encountered in clinical practice may have extenuating features such that they may not fit exactly into any of the clinical scenarios presented.

It is understood that procedures whose use is Appropriate or May Be Appropriate should be reimbursed when applied in the suitable clinical scenario. In certain clinical settings, procedures that are Rarely Appropriate may be justifiable based on that patient's particular clinical characteristics. These exceptions should be clearly documented.

Additionally, it is assumed that the evaluation for SIHD in these clinical scenarios occurs in a nonurgent setting. Thus, despite the recent publication of 3 randomized comparative effectiveness trials of the use of CCTA in the emergency department evaluation of low risk but acute chest pain (58−60), the use of CCTA for this specific clinical scenario is not addressed in this document because the intended focus is for the outpatient evaluation of SIHD (61).

As with prior AUC documents, we anticipate that the interpretation and application of these criteria will yield insights into patterns of care and will help to inform future iterations of these criteria. The ratings in the present document will be re-evaluated on a regular basis as the modalities, the evidence base, and the clinical landscape evolve. In addition, future documents will rate clinical scenarios involving cardiac structure and function assessment.

9. Conclusions

In summary, this document presents for the first time, side-by-side ratings of the multiple tests that are available to the clinician for the detection of SIHD or risk assessment purposes in the setting of 80 common scenarios. The document is not intended to foster or imply competition amongst modalities. It is intended to provide a practical guide to individual clinicians and patients when considering 1 of these procedures, based on any number of important local and patient-specific variables, while promoting optimal test utilization for the population at large. Recognizing that many modalities are available for clinical decision making, it is anticipated that compiling these modalities into 1 document will help clarify, for clinicians, patients, and payers, when certain procedures are Appropriate, are May Be Appropriate, or are Rarely Appropriate in patients with known or suspected SIHD.

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Appendix A: Additional Methods

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

Relationships With Industry and Other Entities

The College 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 panelists 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 working group members can be found in Appendix C.

Appendix B: ACCF 2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Ischemic Heart Disease Participants

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Appendix C: ACCF Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Ischemic Heart Disease Writing Group, Technical Panel, Task Force, and Indication Reviewers—Relationships with Industry and Other Entities (Relevant)

A standard exemption to the ACCF relationships with industry (RWI) policy is extended to Appropriate Use Criteria writing committees which do not make recommendations but rather prepare background materials and typical clinical scenarios/indications that are rated independently by a separate technical panel.

Participant	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Detection And Risk Assessment Of Stable Ischemic Heart Disease Writing Group						
Steven R. Bailey	None	None	None	None	None	None
John U. Doherty	None	None	None	None	None	None
Pamela S. Douglas	None	None	None	None	None	None
Robert C. Hendel	None	None	None	None	None	None
Christopher M. Kramer	• St. Jude Medical	None	None	None	None	None
James K. Min	None	None	None	None	None	None
Manesh R. Patel	None	None	None	None	None	None
Lisa Rosenbaum	None	None	None	None	None	None
Leslee J. Shaw	None	None	None	None	None	None
Raymond F. Stainback	None	None	None	None	None	None
Michael J. Wolk	None	None	None	None	None	None
Joseph M. Allen	None	None	None	None	None	None
Detection And Risk Assessment Of Stable Ischemic Heart Disease Technical Panel						
Ralph G. Brindis	None	None	None	None	None	None
Manuel D. Cerqueira	• Astellas Pharma US* • FluoroPharma* • GE Healthcare*	• Astellas Pharma US* • GE Healthcare*	None	• Perceptive Informatics*	None	None
Jersey Chen	• Lantheus	None	None	• Agency for Healthcare Quality and Research* • American Heart Association*	None	None
Larry S. Dean	• Philips Medical*	• Daiichi Sankyo • Lilly	None	• Edwards Life Sciences*	• Emageon	None
Reza Fazel	None	None	None	None	None	None
W. Gregory Hundley	None	None	None	None	None	None
Dipti Itchhaporia	None	None	None	None	None	None
Paul Kligfield	• GE HealthCare • Mortara Instrument	None	• Unilead International	None	• American Heart Association	None
Christopher M. Kramer	• St. Jude Medical	None	None	None	None	None
Richard Lockwood	None	None	None	None	None	None
Joseph Edward Marine	None	None	None	None	None	None
Robert Benjamin McCully	None	None	None	None	None	None
Joseph V. Messer	None	None	None	None	None	None
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Richard J. Shemin	• Atricure • Edwards LifeSciences	None	None	None	None	None
L. Samuel Wann	• United Healthcare	None	None	None	None	None

John B. Wong	None	None	None	• Agency for Healthcare Research and Quality* • Foundation for Informed Medical Decision Making* • National Heart, Lung and Blood Institute*	None	None
Detection And Risk Assessment Of Ischemic Heart Disease Reviewers						
Jeffrey L Anderson	None	None	None	• GlaxoSmithKline • TIMI-48, 51, 52, and 54 • Toshiba	• COAG Study (Data Safety Monitoring Board)* • EMBRACE-STEMI Study, ICON • GIFT Study • ISCHEMIA Study, NIH	None
Salman A. Arain	None	• St. Jude's Medical Center	None	None	None	None
James Blankenship	None	None	None	• Abiomed • Astra-Zeneca • Boston Scientific • Kai Pharmaceutical • Novartis Schering-Plough • The Medicines Company • Volcano Corporation	• American Medical Association • Society for Angiography and Interventions	None
Javed Butler	None	None	None	None	None	None
Charles E. Chambers,	None	None	None	None	None	None
Mehmet Cilingiroglu,	None	None	None	None	None	None
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Jeanne M. DeCara	None	None	None	None	None	None
Gregory Dehmer	• Clinical Advisory Group, Maryland Health Care Commission • Food and Drug Administration, Circulatory System Devices, Panel of the Medical Devices	None	None	None	• Accreditation for Cardiovascular Excellence • Scott & White Healthcare • Society for Cardiovascular Angiography and Interventions	None
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Richard Fuchs	None	None	None	None	None	None
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Smadar Kort	Premier	None	None	None	• Boston Scientific*	None

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Participant	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
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Kartik Mani	• Medtronic	None	None	None	None	None
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Warren Manning	None	None	None	• Philips Medical*	None	None
David May	None	None	None	None	None	None
Venu Menon	None	None	None	None	None	None
Greg Mishkel	None	None	None	None	None	None
Eike Nagel	• Bayer Healthcare • Philips Healthcare	None	None	• Bayer Healthcare • Philips Healthcare*	None	None
Ayan Patel	None	None	None	None	None	None
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Katherine Wu	None	None	None	None	None	None
R. Eugene Zierler	None	None	None	None	None	None
Appropriate Use Criteria Task Force						
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Alan S. Brown	None	None	None	None	None	None
John U. Doherty	None	None	None	None	None	None
Pamela S. Douglas	None	None	None	None	None	None
Robert C. Hendel	None	None	None	None	None	None
Christopher M. Kramer	• St. Jude Medical	None	None	None	None	None
Bruce D. Lindsay	• Boston Scientific • Medtronic	None	None	None	• Boston Scientific* • Medtronic* • St. Jude Medical*	None
James K. Min	None	None	None	None	None	None
Manesh R. Patel	None	None	None	None	None	None
Leslee J. Shaw	None	None	None	None	None	None
Raymond F. Stainback	None	None	None	None	None	None
L. Samuel Wann	None	None	None	None	None	None
Michael J. Wolk	None	None	None	None	None	None
Joseph M. Allen	None	None	None	None	None	None

This table represents the relevant relationships with industry and other entities that were disclosed by participants at the time of participation. It does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of 5% or more of the voting stock or share of the business entity, or ownership of $10,000 or more of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. A relationship is considered to be modest if it is less than significant under the preceding definition. Relationships in this table are modest unless otherwise noted. Names are listed in alphabetical order within each category of review. Participation does not imply endorsement of this document.

*Significant (>$10,000) relationship.