APPROPRIATE USE CRITERIA

ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS 2017 Appropriate Use Criteria for Coronary Revascularization in Patients With Stable Ischemic Heart Disease

A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and Society of Thoracic Surgeons

The American College of Cardiology, Society for Cardiovascular Angiography and Interventions, Society of Thoracic Surgeons, and American Association for Thoracic Surgery, along with key specialty and subspecialty societies, have completed a 2-part revision of the appropriate use criteria (AUC) for coronary revascularization. In prior coronary revascularization AUC documents, indications for revascularization in acute coronary syndromes and stable ischemic heart disease (SIHD) were combined into 1 document. To address the expanding clinical indications for coronary revascularization, and to align the subject matter with the most current American College of Cardiology/American Heart Association guidelines, the new AUC for coronary artery revascularization were separated into 2 documents addressing SIHD and acute coronary syndromes individually. This document presents the AUC for SIHD.

Clinical scenarios were developed to mimic patient presentations encountered in everyday practice. These scenarios included information on symptom status; risk level as assessed by noninvasive testing; coronary disease burden; and, in some scenarios, fractional flow reserve

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testing, presence or absence of diabetes, and SYNTAX score. This update provides a reassessment of clinical scenarios that the writing group felt were affected by significant changes in the medical literature or gaps from prior criteria. The methodology used in this update is similar to the initial document but employs the recent modifications in the methods for developing AUC, most notably, alterations in the nomenclature for appropriate use categorization.

A separate, independent rating panel scored the clinical scenarios on a scale of 1 to 9. Scores of 7 to 9 indicate that revascularization is considered appropriate for the clinical scenario presented. Scores of 1 to 3 indicate that revascularization is considered rarely appropriate for the clinical scenario, whereas scores in the mid-range of 4 to 6 indicate that coronary revascularization may be appropriate for the clinical scenario.

As seen with the prior coronary revascularization AUC, revascularization in clinical scenarios with high symptom burden, high-risk features, and high coronary disease burden, as well as in patients receiving antianginal therapy, are deemed appropriate. Additionally, scenarios assessing the appropriateness of revascularization before kidney transplantation or transcatheter valve therapy are now rated. The primary objective of the AUC is to provide a framework for the assessment of practice patterns that will hopefully improve physician decision making.

Key Words: Appropriate Use Criteria • coronary revascularization • imaging • medical therapy • multimodality

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PREFACE

The American College of Cardiology (ACC), in collaboration with the Society for Cardiovascular Angiography and Interventions, Society of Thoracic Surgeons, American Association for Thoracic Surgery, and other societies, developed and published the first version of the AUC for coronary revascularization in 2009, releasing the last update in 2012. The AUC are an effort to assist clinicians in the rational use of coronary revascularization in common clinical scenarios found in everyday practice. The new AUC for coronary revascularization were developed as separate documents for stable ischemic heart disease (SIHD) and acute coronary syndromes. This was done to address the expanding clinical indications for coronary revascularization, include new literature published since the last update, and align the subject matter with the ACC/American Heart Association guidelines. An additional goal was to address several of the shortcomings of the initial document that became evident as experience with the use of the AUC accumulated in clinical practice.

The publication of AUC reflects 1 of several ongoing efforts by the ACC and its partners to assist clinicians who are caring for patients with cardiovascular diseases and to support high-quality cardiovascular care. The ACC/American Heart Association clinical practice guidelines provide a foundation for summarizing evidence-based cardiovascular care and, when evidence is lacking, provide expert consensus opinion that is approved in review by the ACC and American Heart Association. However, in many areas, variability remains in the use of cardiovascular procedures, raising questions of over- or underuse. The AUC provide a practical standard upon which to assess and better understand variability.

We are grateful to the writing committee for the development of the overall structure of the document and clinical scenarios and to the rating panel—a professional group with a wide range of skills and insights—for their thoughtful deliberation on the merits of coronary revascularization for various clinical scenarios. We would also like to thank the parent AUC Task Force and the ACC staff—Joseph Allen, Leah White, and specifically, Maria Velasquez—for their skilled support in the generation of this document.

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INTRODUCTION

In a continuing effort to provide information to patients, physicians, and policy makers, the Appropriate Use Task Force approved this revision of the 2012 Coronary Revascularization AUC.[1] Since publication of the 2012 AUC focused update, the original nomenclature used to characterize appropriate use has changed.[2] New clinical practice guidelines (CPGs) for SIHD have been released, and new clinical trials extending the knowledge and evidence around coronary revascularization have been published.[3,4] These trials include studies not only on the use of percutaneous coronary intervention (PCI), but also on coronary artery bypass graft surgery (CABG), medical therapy, and diagnostic technologies such as fractional flow reserve (FFR) to guide revascularization.[5–8] Additional studies, some based on data from the National Cardiovascular Data Registry (NCDR), have been published providing insights into practice patterns and information around clinical scenarios and patient features not previously addressed.[9–13]

Improvements in our understanding of the variables affecting patient outcomes before and after coronary revascularization, continued emphasis on the role of medical therapy for coronary artery disease (CAD), and an increasing emphasis on shared decision making and patient preferences also make a revision of the coronary revascularization AUC timely.[14] This document focuses on SIHD and is a companion to the AUC specifically for acute coronary syndromes.

METHODS

Indication Development

A multidisciplinary writing group consisting of cardiovascular health outcomes researchers, interventional

cardiologists, cardiothoracic surgeons, and general cardiologists was convened to review and revise the prior coronary revascularization AUC. The writing group was tasked with developing clinical indications (scenarios) that reflect typical situations encountered in everyday practice that were then rated by a technical panel. In this document, the term ''indication'' is used interchangeably with the phrase ''clinical scenario.'' Critical data elements and mapping of the criteria to the elements will be provided for end-users of the revascularization AUC so that procedure notes and chart abstraction can be more easily mapped to the AUC. A key goal of this effort is to leverage the NCDR (National Cardiovascular Data Registry) CathPCI registry to map indications to appropriateness ratings, so that minimal additional data collection is needed to support quarterly feedback to the sites of their performance as a foundation for improving patient selection for revascularization. The AUC Task Force is committed to supporting linkage of the AUC with daily workflow to capture the data elements needed for AUC ratings.

The revascularization AUC are based on our current understanding of procedure outcomes plus the potential patient benefits and risks of the revascularization strategies examined. Although the AUC are developed to address many of the common clinical scenarios encountered in practice, it would be impossible to include every conceivable patient presentation and maintain a workable document for clinicians. The writing group acknowledges that the current AUC do not evaluate all patient variables that might affect 1 or more strategies for the management of patients with CAD. Examples of conditions not explicitly considered within the scenarios include severe chronic kidney disease, severe peripheral vascular disease, known malignancies, poor lung function, advanced liver disease, advanced dementia, and/or other comorbidities that might have excluded patients from the clinical trials that provide the evidence base for coronary revascularization. Nevertheless, it is necessary for the clinician to include these conditions in the final decision-making process for an individual patient, and this may result in the actual therapy deviating from the AUC rating. It is expected that all clinicians will occasionally treat patients with extenuating conditions that are not captured in the current AUC, and this could result in a treatment rating of ''rarely appropriate'' for the chosen therapy in a specific patient. However, these situations should not constitute a majority of treatment decisions, and it is presumed that they will affect all practitioners equally, thereby minimizing substantial biases in assessing the performance of individual clinicians compared with their peers. Additionally, these AUC were developed in parallel with efforts to update data collection within the NCDR registries to include data fields that capture some of these extenuating circumstances, thereby improving the characterization of scenarios in the AUC.

AUC documents often contain specific clinical scenarios rather than the more generalized situations covered in CPGs; thus, subtle differences between these documents may exist. The treatment of patients with SIHD should always include therapies to modify risk factors and/or reduce cardiovascular events—so-called secondary prevention. In several CPGs, the phrase ''guideline-directed medical therapy'' is used and, depending on the context, may include the use of antianginal therapy in addition to therapies for secondary prevention. In this AUC, it is assumed that all patients will be receiving comprehensive secondary prevention therapies as needed. Antianginal therapy has a central role in the treatment of patients with SIHD. In some patients, it may be the sole therapy, whereas in others it may be continued, albeit in lower doses, following a revascularization procedure. The earlier coronary revascularization AUC included information about the intensity of antianginal therapy in several scenarios, with language such as ''receiving no or minimal anti-ischemic therapy'' or ''receiving a course of maximal anti-ischemic therapy.'' The new AUC adopt a different format, including options for the initiation or escalation of antianginal therapy patterned after recommendations made in the 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the Diagnosis and Management of Patients With Stable Ischemic Heart Disease (2012 SIHD guideline),[3] using a structure that mimics clinical practice. However, the primary purpose of these AUCs is to rate the appropriateness of revascularization with the understanding that decisions about revascularization are frequently made in the context of ongoing antianginal therapy. Because recommendations for revascularization or the medical management of CAD are found throughout several CPGs, the AUC ratings herein are meant to unify related CPGs and other data sources and provide a useful tool for clinicians.

These AUC were developed with the intent of assisting patients and clinicians, but they are not intended to diminish the acknowledged complexity or uncertainty of clinical decision making and should not be used as a substitute for sound clinical judgment. There are acknowledged evidence gaps in many areas where clinical judgment and experience must be blended with patient preferences and the existing knowledge base defined in CPGs. It is important to emphasize that a rating of *appropriate care* does not mandate that a revascularization procedure be performed; likewise, a rating of *rarely appropriate care* should not prevent a revascularization procedure from being performed. It is anticipated, as noted in the previous text, that there will be occasional clinical scenarios rated *rarely appropriate* in which performing revascularization may still be in the best interest of a particular patient. In situations in which the AUC rating is not followed, clinicians should document the specific patient features not captured in the clinical scenario or the rationale for the chosen therapy. Depending on the urgency of care, convening a heart team or obtaining a second opinion may be helpful in some of these settings.

The AUC can be used in several ways. As a clinical tool, the AUC assist clinicians in evaluating possible therapies under consideration and can help better inform patients about their therapeutic options. As an administrative and research tool, the AUC provide a means of comparing utilization patterns among providers to thereby derive an assessment of an individual clinician's management strategies compared with his/her peers. It is critical to understand that the AUC should be used to assess an overall pattern of clinical care rather than being the final arbitrator of specific individual cases. The ACC and its collaborators believe that an ongoing review of one's

practice using these criteria will help guide more effective, efficient, and equitable allocation of healthcare resources, and ultimately, better patient outcomes. **However, under no circumstances should the AUC be used to adjudicate or determine payment for individual patients. Rather, the intent of the AUC is to provide a framework to evaluate overall clinical practice patterns and improve the quality of care.**

In developing these AUC for coronary revascularization, the rating panel was asked to rate each indication using the following definition of appropriate use:

> *A coronary revascularization is appropriate care when the potential benefits, in terms of survival or health outcomes (symptoms, functional status, and/or quality of life), exceed the potential negative consequences of the treatment strategy.*

The rating panel scored each indication on a scale from 1 to 9 as follows:

Score 7 to 9: Appropriate care
Score 4 to 6: May be appropriate care
Score 1 to 3: Rarely appropriate care

Appropriate Use Definition and Ratings

In rating these criteria, the rating panel was asked to assess whether the use of revascularization for each indication is ''appropriate care,'' ''may be appropriate care,'' or is ''rarely appropriate care'' using the following definitions and their associated numeric ranges. Anonymized individual scores are available in an online appendix.

Median Score 7 to 9: Appropriate Care. An appropriate option for management of patients in this population, as the benefits generally outweigh the risks; an 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 to risk ratio, potential benefit based on practice experience in the absence of evidence, and/or variability in the population; effectiveness for individual care must be determined by a patient's physician in consultation with the patient on the basis of 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).

The process for development of the AUC is shown in Figure 1 and described in detail in previous documents.[1,2]

After completion and tabulation of the second round of ratings, it became apparent to the writing group that the original structure of certain rating tables may have confused some members of the rating panel, causing ratings that were not internally consistent. This resulted in a re-evaluation and redesign of the rating table structure, which then required a third round of ratings. This AUC document presents the end result of that process and the results of the third round of ratings.

Scope of Indications

The indications for coronary revascularization in SIHD were developed considering the following common variables:

1. The clinical presentation (e.g., low or high activity level to provoke ischemic symptoms);
2. Use of antianginal medications;
3. Results of noninvasive tests to evaluate the presence and severity of myocardial ischemia;
4. Presence of other confounding factors and comorbidities such as diabetes;
5. Extent of anatomic disease;
6. Prior coronary artery bypass surgery; and
7. Invasive testing such as intravascular ultrasound (IVUS) and invasive physiology such as FFR.

The anatomic construct for CAD is based on the presence or absence of flow-limiting obstructions in the coronary arteries categorized by the number of vessels involved (1-, 2-, and 3-vessel, and/or left main CAD). Additionally, we included in the anatomic construct the presence or absence of proximal left anterior descending (LAD) disease. This specific stenosis location was identified in both the 2011 ACCF/AHA guideline for coronary artery bypass graft surgery (2011 CABG guidelines) and 2012 ACC/AHA/SCAI guideline for percutaneous coronary intervention (2012 PCI guidelines) and was included in the clinical trial recruitment to guide revascularization decisions.[6,15,16] Other factors such as diabetes and the complexity of disease were included in certain clinical scenarios given their effect on cardiac risk and association with more favorable outcomes from surgical revascularization. As before, noninvasive test findings are included in many scenarios to distinguish patients with a low risk for future adverse events from those with intermediate- or high-risk findings, as these terms are routinely used in clinical practice.

Antianginal treatment of CAD is incorporated into the structure of the tables following the pattern of recommendations in the SIHD guideline (see 2012 SIHD guidelines, Section 4.4.3.1.) but without specific drug or dose recommendations.[3,4] In general, beta blockers are recommended as the initial treatment for symptom relief (Class I recommendation), with calcium channel blockers, long-acting nitrates, or ranolazine prescribed in combination with beta blockers when initial treatment with beta blockers is inadequate to control symptoms despite appropriate dosing. Calcium channel blockers, long-acting nitrates, or ranolazine should be

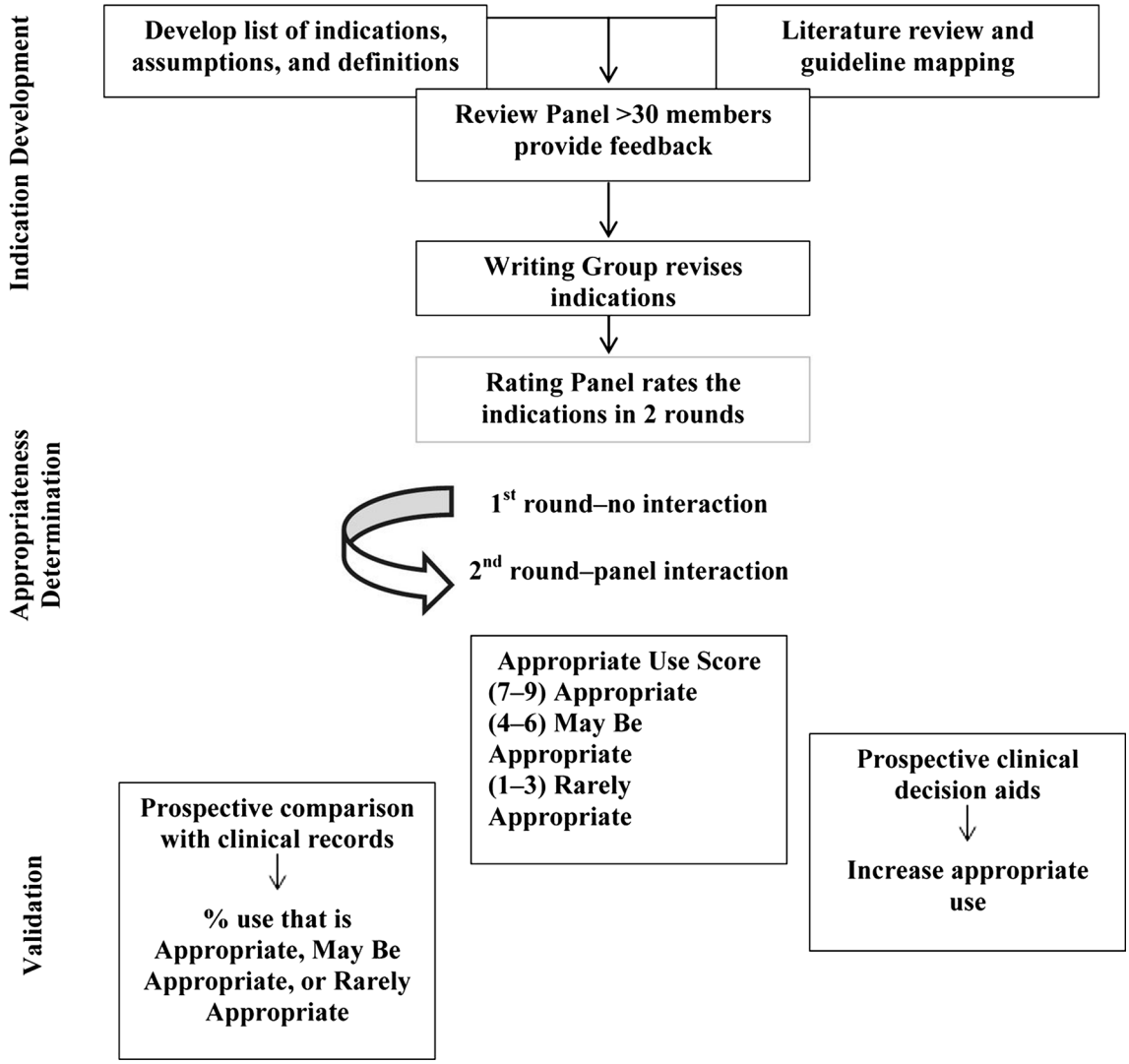

Figure 1. AUC Development Process
AUC indicates appropriate use criteria

prescribed for relief of symptoms when beta blockers are contraindicated or cause unacceptable side effects. Long-acting nondihydropyridine calcium channel blockers are reasonable alternatives to beta blockers as first-line therapy for antianginal symptoms (Class IIa, Level of Evidence: B). The use of FFR was incorporated to a greater extent than in the previous AUC as more data on the usefulness of this testing modality have emerged.

ASSUMPTIONS

General Assumptions

Specific assumptions provided to the rating panel for their use in rating the relevant clinical scenarios are summarized in the following text.

1. When available, each clinical scenario includes the patient's clinical status/symptom complex, ischemic burden as determined by noninvasive functional testing, burden of coronary atherosclerosis as determined by angiography, and additional invasive testing evaluations by invasive physiology (e.g., FFR, instantaneous wave-free ratio) or intravascular imaging.
2. When utilized, stress testing, with or without an associated imaging procedure, was performed correctly and with sufficient quality to produce a meaningful and accurate result within the limits of the test performance. Evidence of myocardial viability is also an important finding and in some clinical situations may influence the decision for

revascularization, but it was not used to further expand the number of indications.

3. As the main focus of this AUC is revascularization, assume that coronary angiography has been performed. The rating panel should judge the appropriateness of revascularization on the basis of the clinical scenario presented, including the coronary disease identified, independent of a judgment about the appropriateness of the coronary angiogram in the scenario.
4. Assume no other significant coronary artery stenoses are present except those specifically described in the clinical scenario.
5. A significant coronary stenosis for the purpose of the clinical scenarios is defined as:
   - ≥70% luminal diameter narrowing, by visual assessment, of an epicardial stenosis measured in the ''worst view'' angiographic projection;
   - ≥50% luminal diameter narrowing, by visual assessment, of a left main stenosis measured in the ''worst view'' angiographic projection; or
   - 40% to 70% luminal narrowing, by visual assessment, of an epicardial stenosis measured in the ''worst view'' angiographic projection with an abnormal FFR as defined in the following text.
6. An FFR ≤0.80 is abnormal and is consistent with downstream inducible ischemia.
7. All patients included in these scenarios are receiving needed therapies to modify existing risk factors as outlined in CPGs and other documents.[17–19] Despite the best efforts of the clinician, all patients may not achieve target goals for cardiac risk factor modification. However, a continuing effort and plan of care to address risk factors are assumed to exist.
8. For patients with SIHD, the writing group recognizes there are many choices for antianginal therapy and considerable variation in the use and tolerance of antianginal medications among patients. The use of antianginal therapy adopted in this AUC follows the recommendations of the SIHD guideline. Assume that antianginal therapy is prescribed at a dose that adequately controls the patient's symptoms or is the maximally tolerated dose for a particular drug.
9. Operators performing percutaneous or surgical revascularization have appropriate clinical training and experience and have satisfactory outcomes as assessed by quality assurance monitoring.[15,20,21]
10. Revascularization by either percutaneous or surgical methods is performed in a manner consistent with the established standards of care at centers with quality/volume standards.[15,20,21]
11. In the clinical scenarios, no unusual extenuating circumstances exist (e.g., an inability to comply with antiplatelet agents, do-not-resuscitate status, a patient unwilling to consider revascularization, technical reasons rendering revascularization infeasible, or comorbidities likely to markedly increase procedural risk). If any of these circumstances exist, it is critical that the clinician provide adequate documentation in the medical record to support exclusions from the AUC and the alternative management decisions made in the patient.
12. Patient history and physical examination are assumed to be comprehensive and thorough. Descriptions of the patient's symptoms are assumed to accurately represent the current status of the patient (e.g., asymptomatic patients are truly asymptomatic rather than asymptomatic due to self-imposed lifestyle limitations).
13. When PCI is being considered in patients with multivessel disease, it may be clinically prudent to perform the procedures in a sequential fashion (so-called ''staged procedures''). If this is the initial management plan, the intent for a staged procedure should be clearly outlined and the appropriateness rating should apply to the entire revascularization procedure. Specifically, *planned staged procedures* should not be assessed by individual arteries but rather in terms of the plan for the entire revascularization strategy. For data collection purposes, this will require documenting how the procedure is staged (either PCI or hybrid revascularization with surgery), and it is assumed that all stenoses covered under the umbrella of the planned staged procedure are functionally significant.
14. Although the clinical scenarios should be rated on the basis of the published literature, the writing committee acknowledges that decisions about coronary artery revascularization in patient populations that are poorly represented in the literature are still required in daily practice. Therefore, rating panel members should assume that some of the clinical scenarios presented will have low levels of evidence to guide rating decisions. Key to the application of the AUC in settings where there are extenuating circumstances or low levels of supporting evidence is enhanced documentation by the clinician to support the clinical decisions made.
15. As with all previously published clinical policies, deviations by the rating panel from prior published documents were directed by new evidence 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.

16. Indication ratings contained herein supersede the ratings of similar indications contained in previous AUC coronary revascularization documents.

Assumptions for Rating Multiple Treatment Options

1. The goal of this document is to identify revascularization treatments that are considered reasonable for a given clinical indication. Therefore, each treatment option (PCI or CABG) should be rated independently for its level of appropriateness in the specific clinical scenario, rather than being placed into a forced or artificial rank-order comparison against each other. Identifying options that may or may not be reasonable for specific indications is the goal of this document, **rather than determining a single best treatment for each clinical indication or a rank-order.** Therefore, more than 1 treatment or even all treatments may be considered ''Appropriate,'' ''May Be Appropriate,'' or ''Rarely Appropriate'' for any given clinical indication.
2. If more than 1 treatment falls into the same appropriate use category, it is assumed that patient preference combined with physician judgment and available local expertise will be used to determine the final treatment used.

DEFINITIONS

Definitions of some key terms used throughout the scenarios are shown in the following text. A complete set of definitions is found in Appendix 1. These definitions were provided to and discussed with the rating panel before the rating process started.

Indication

A set of patient-specific conditions defines an ''indication.'' The term ''clinical indication'' (used interchangeably with ''clinical scenario'') provides the context for the rating of therapeutic options. However, an ''appropriate'' rating assigned by the rating panel does not necessarily mean the therapy is mandatory, nor does a ''rarely appropriate'' rating mean it is prohibited.

Risk Factor Modification (Secondary Prevention) and Antianginal Medical Therapy

As previously stated, the indications assume that patients are receiving all indicated treatments for the secondary prevention of cardiovascular events. This includes lifestyle and pharmacological interventions according to guideline-based recommendations. Antianginal medical therapy is incorporated into the structure of the rating tables and should follow the recommendations of the SIHD guideline, with a beta blocker as initial therapy and the option to administer calcium channel blockers, long-acting nitrates, and/or ranolazine if the beta blocker is ineffective or not tolerated.[3,4]

Specific target doses of drugs are not provided as this must be individualized, but for beta blockers, it is assumed that the dose is sufficient to blunt the exercise heart rate without causing intolerable fatigue, bradycardia, or hypotension. It is assumed that the maximally tolerated dose of beta blockers is being used before the addition of other drugs, and when other drugs are added, the dose is titrated to alleviate symptoms or is also the maximally tolerated dose. Using multiple drugs at less optimal doses is an inefficient and expensive strategy. The SIHD guideline recommends calcium channel blockers or long-acting nitrates if beta blockers are contraindicated or cause unacceptable side effects. The SIHD guideline also recommends adding calcium channel blockers or long-acting nitrates to beta blockers for relief of symptoms when initial treatment with beta blockers is unsuccessful. Initiating, continuing, or intensifying antianginal therapy is integrated into the ratings tables along with revascularization options, as this is typical of real-world practice.

Stress Testing and Risk of Findings on Noninvasive Testing

Stress testing is commonly used for both diagnosis and risk stratification of patients with CAD. Therapies to improve survival in patients with SIHD are outlined in detail in the 2012 SIHD guideline (Table 1).[3] The various noninvasive findings associated with high (>3% annual death or myocardial infarction), intermediate (1% to 3% annual death or myocardial infarction), and low (<1% annual death or myocardial infarction) risk are outlined in Table 2. It is important to note that this table includes several noninvasive findings apart from a stress test, such as resting LV function and a high coronary calcium score in the assessment of risk. These were not specifically included in the indications of this AUC, but should be considered as part of the patient profile described in an indication, especially when high and intermediate risk are used in the indication.

Vessel Disease

The construct used to characterize the extent of CAD is based on the common clinical use of the terms 1-, 2-,

Table 1. Revascularization to improve survival compared with medical therapy

Anatomic Setting	COR	LOE	References
UPLM or complex CAD			
CABG and PCI	I—Heart Team approach recommended	C	(950–952)
CABG and PCI	IIa—Calculation of STS and SYNTAX scores	B	(949,950,953–957)
UPLM*			
CABG	I	B	(73,381,412,959–962)
PCI	IIa—For SIHD when *both* of the following are present: ■ Anatomic conditions associated with a low risk of PCI procedural complications and a high likelihood of good long-term outcome (e.g., a low SYNTAX score of ≤22, ostial or trunk left main CAD) ■ Clinical characteristics that predict a significantly increased risk of adverse surgical outcomes (e.g., STS-predicted risk of operative mortality ≥5%)	B	(949,953,955,958,963–980)
	IIa—For UA/NSTEMI if not a CABG candidate	B	(949,968–971,976–979,981)
	IIa—For STEMI when distal coronary flow is TIMI flow grade <3 and PCI can be performed more rapidly and safely than CABG	C	(965,982,983)
	IIb—For SIHD when *both* of the following are present: ■ Anatomic conditions associated with a low to intermediate risk of PCI procedural complications and an intermediate to high likelihood of good long-term outcome (e.g., low-intermediate SYNTAX score of <33, bifurcation left main CAD) ■ Clinical characteristics that predict an increased risk of adverse surgical outcomes (e.g., moderate—severe COPD, disability from prior stroke, or prior cardiac surgery; STS-predicted operative mortality >2%)	B	(949,953,955,958,963–980,984)
	III: Harm—For SIHD in patients (versus performing CABG) with unfavorable anatomy for PCI and who are good candidates for CABG	B	(73,381,412,949,953,955,959–964)
3-vessel disease with or without proximal LAD artery disease*			
CABG	I	B	(353,412,959,985–987)
	IIa—It is reasonable to choose CABG over PCI in patients with complex 3-vessel CAD (e.g., SYNTAX score >22) who are good candidates for CABG.	B	(964,980,987–989)
PCI	IIb—Of uncertain benefit	B	(366,959,980,985,987)
2-vessel disease with proximal LAD artery disease*			
CABG	I	B	(353,412,959,985–987)
PCI	IIb—Of uncertain benefit	B	(366,959,985,987)
2-vessel disease without proximal LAD artery disease*			
CABG	IIa—With extensive ischemia	B	(327,990–992)
	IIb—Of uncertain benefit without extensive ischemia	C	(987)
PCI	IIb—Of uncertain benefit	B	(366,959,985,987)
1-vessel proximal LAD artery disease			
CABG	IIa—With LIMA for long-term benefit	B	(412 987,993,994)
PCI	IIb—Of uncertain benefit	B	(366,959,985,987)
1-vessel disease without proximal LAD artery involvement			
CABG	III: Harm	B	(306,327,412,985,990,995–998)
PCI	III: Harm	B	(306,327,412,985,990,995–998)
LV dysfunction			
CABG	IIa—EF 35% to 50%	B	(365,412,999–1002)
CABG	IIb—EF <35% without significant left main CAD	B	(355,365,410,412,999–1002)
PCI	Insufficient data		N/A
Survivors of sudden cardiac death with presumed ischemia-mediated VT			
CABG	I	B	(350,1003,1004)
PCI	I	C	(1003)
No anatomic or physiological criteria for revascularization			
CABG	III: Harm	B	(306,327,412,985,990,995–998)
PCI	III: Harm	B	(306,327,412,985,990,995–998)

*In patients with multivessel disease who also have diabetes mellitus, it is reasonable to choose CABG (with LIMA) over PCI (30,991,1005–1011) (*Class IIa; LOE: B*)
Reproduced from Fihn et al. [3]
CABG, coronary artery bypass graft; *CAD*, coronary artery disease; *COPD*, chronic obstructive pulmonary disease; *COR*, class of recommendation; *EF*, ejection fraction; *LAD*, left anterior descending; *LIMA*, left internal mammary artery; *LOE*, level of evidence; *LV*, left ventricular; *N/A*, not available; *PCI*, percutaneous coronary intervention; *SIHD*, stable ischemic heart disease; *STEMI*, ST-elevation myocardial infarction; *STS*, Society of Thoracic Surgeons; *SYNTAX*, Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery; *TIMI*, Thrombolysis In Myocardial Infarction; *UA/NSTEMI*, unstable angina/nonST-elevation myocardial infarction; *UPLM*, unprotected left main disease; *VT*, ventricular tachycardia

Table 2. Noninvasive risk stratification

High risk (>3% annual death or MI)

1. Severe resting LV dysfunction (LVEF <35%) not readily explained by noncoronary causes
2. Resting perfusion abnormalities ≥10% of the myocardium in patients without prior history or evidence of MI
3. Stress ECG findings including ≥2 mm of ST-segment depression at low workload or persisting into recovery, exercise-induced ST-segment elevation, or exercise-induced VT/VF
4. Severe stress-induced LV dysfunction (peak exercise LVEF <45% or drop in LVEF with stress ≥10%)
5. Stress-induced perfusion abnormalities encumbering ≥10% myocardium or stress segmental scores indicating multiple vascular territories with abnormalities
6. Stress-induced LV dilation
7. Inducible wall motion abnormality (involving >2 segments or 2 coronary beds)
8. Wall motion abnormality developing at low dose of dobutamine (≤10 mg/kg/min) or at a low heart rate (<120 beats/min)
9. CAC score >400 Agatston units
10. Multivessel obstructive CAD (≥70% stenosis) or left main stenosis (≥50% stenosis) on CCTA

Intermediate risk (1% to 3% annual death or MI)

1. Mild/moderate resting LV dysfunction (LVEF 35% to 49%) not readily explained by noncoronary causes
2. Resting perfusion abnormalities in 5% to 9.9% of the myocardium in patients without a history or prior evidence of MI
3. ≥1 mm of ST-segment depression occurring with exertional symptoms
4. Stress-induced perfusion abnormalities encumbering 5% to 9.9% of the myocardium or stress segmental scores (in multiple segments) indicating 1 vascular territory with abnormalities but without LV dilation
5. Small wall motion abnormality involving 1 to 2 segments and only 1 coronary bed
6. CAC score 100 to 399 Agatston units
7. One-vessel CAD with ≥70% stenosis or moderate CAD stenosis (50% to 69% stenosis) in ≥2 arteries on CCTA

Low risk (<1% annual death or MI)

1. Low-risk treadmill score (score ≥5) or no new ST-segment changes or exercise-induced chest pain symptoms; when achieving maximal levels of exercise
2. Normal or small myocardial perfusion defect at rest or with stress encumbering <5% of the myocardium*
3. Normal stress or no change of limited resting wall motion abnormalities during stress
4. CAC score <100 Agatston units
5. No coronary stenosis >50% on CCTA

*Although the published data are limited; patients with these findings will probably not be at low risk in the presence of either a high-risk treadmill score or severe resting LV dysfunction (LVEF <35%)
Reproduced from Fihn et al.[3]
CAC, coronary artery calcium; *CAD*, coronary artery disease; *CCTA*, coronary computed tomography angiography; *LV*, left ventricular, *LVEF*, left ventricular ejection fraction; *MI*, myocardial infarction

and 3-vessel disease and left main disease, although it is recognized that individual coronary anatomy is highly variable. In general, these terms refer to a significant stenosis in 1 of the 3 major coronary arteries (right coronary artery, LAD, or circumflex) or their major branches. With the exception of the proximal LAD, which specifically refers to the segment of the LAD proximal to the first major septal and diagonal, the terms 1-, 2-, and 3-vessel disease do not define the location (i.e., proximal, mid, or distal) of the stenosis in the artery, which is frequently related to the amount of myocardium at risk. Furthermore, the classification of diseased vessels does not consider coronary dominance, although in practical terms, most consider individuals with significant disease in the LAD and a left dominant circumflex to have 3-vessel involvement. Coronary anomalies are also not considered in this construct. Although imperfect, the commonly used classification of 1-, 2-, and 3-vessel disease and left main disease remains widely used in clinical practice. Within the context of this document, the terms 1-, 2-, and 3-vessel disease should be assumed to mean that each vessel involved (whether the main vessel or a major side branch) provides flow to a sufficient amount of myocardium to be clinically important. The anatomic definition of 1-, 2-, or 3-vessel disease is now often augmented by the physiological testing of stenosis significance (e.g., FFR), which can reclassify the hemodynamic significance of a

stenosis. In the setting of PCI, when FFR in an artery is >0.80, treatment is deferred and the clinical scenario considered should be reclassified to be consistent with the number of significant stenoses. In other words, if the angiogram suggests 2 significant stenoses, but FFR testing indicates that only 1 is significant, the clinical scenario considered should be from the group with 1-vessel CAD. Although there are considerable data to support FFR-directed PCI treatment as an option, this concept is not well-established for surgical revascularization.[22,23]

Ischemic Symptoms

Angina pectoris is usually described as a discomfort (not necessarily pain) in the chest or adjacent areas. It is variably described as tightness, heaviness, pressure, squeezing, or a smothering sensation. In some patients, the symptom may be a more vague discomfort, a numbness, or a burning sensation. Alternatively, so-called anginal equivalents such as dyspnea, faintness, or fatigue may occur. The location is usually substernal and radiation may occur to the neck, jaw, arms, back, or epigastrium. Isolated epigastric discomfort or pain in the lower mandible may rarely be a symptom of myocardial ischemia. The typical episode of angina pectoris begins gradually and reaches its maximum intensity over a period of minutes. Typical angina pectoris is precipitated by exertion or emotional stress and is relieved within minutes by rest or nitroglycerin. Because of the variation in symptoms that may represent myocardial ischemia, the clinical scenarios are presented using the broad term ''ischemic symptoms'' to capture this concept.

This AUC document is specific for patients with SIHD. Therefore, by definition, there are no Canadian Cardiovascular Society Class 4 patients. Because of the variety of symptoms that may indicate myocardial ischemia, individual patient variation in how they are described and observer variability in the assessment of symptom severity, the writing group chose not to use the Canadian Cardiovascular Society classification system in this document.[24,25] Symptom status of the patient was broadly classified into asymptomatic or simply ischemic symptoms, emphasizing the use of more objective measures of ischemia within each indication to stratify patients into low-risk or intermediate-/high-risk findings.

Invasive Methods of Determining Hemodynamic Significance

The writing group recognizes that not all patients referred for revascularization will have previous noninvasive testing. In fact, there are several situations in which patients may be appropriately referred for coronary angiography on the basis of symptom and ECG presentation and a high pretest probability of CAD. In these settings, there may be situations where angiography shows a coronary narrowing of questionable hemodynamic importance in a patient with symptoms that can be related to myocardial ischemia. In such patients, the use of additional invasive measurements (such as FFR or intravascular ultrasound) at the time of diagnostic angiography may be very helpful in further defining the need for revascularization and may substitute for stress test findings. Accordingly, many of the indications now include FFR test results.

The Role of Patient Preference in the AUC

Patients often make decisions about medical treatments without a complete understanding of their options. Patient participation or shared decision making (SDM) describes a collaborative approach whereby patients are provided with evidence-based information on treatment choices and encouraged to use the information in an informed dialogue with their provider to make decisions that not only use the scientific evidence, but also align with their values, preferences, and lifestyle.[26–28] The alternative decision paradigm, often referred to as medical paternalism, places decision authority with physicians and assigns the patient a more passive role.[29] SDM respects both the provider's knowledge and the patient's right to be fully informed of all care options with their associated risks and benefits. SDM often uses decision aids such as written materials, online modules, or videos to present information about treatment options that help the patient evaluate the risks and benefits of a particular treatment. The most effective decision aids to help patients make truly informed decisions provide relevant facts and videos of real patient perspectives regarding the particular treatment.[30] Many professional organizations now endorse SDM in practice.[31,32]

More than 1 treatment option often exists with no clear evidence identifying the best option. This is compounded when there is variation in experts' recommendations about the best treatment under different circumstances.[33] A challenging situation exists when scientific data suggest 1 treatment is likely to have better outcomes, yet the patient prefers an alternative treatment. Within the context of the AUC, this would be manifest as the patient requesting a therapy with a lower AUC rating (e.g., wanting a therapy rated as *rarely appropriate* when a therapy rated *appropriate* exists). Informed consent is fundamental to SDM.[34] Without understanding the pros and cons of all treatment options,

patients cannot properly engage in SDM and blend their personal desires with the scientific data. Without question, it is important that blending AUC ratings into clinical decision making provide a pathway for including patient preference and SDM. However, the mechanism for that process is beyond the scope of this AUC document. The purpose of this document is to develop clinical scenarios and provide ratings of those scenarios by an expert panel. A complete discussion about treatment options with SDM can only be finalized once the category of appropriate use is determined.

ABBREVIATIONS

AA = antianginal
ACS = acute coronary syndrome
AUC = appropriate use criteria
BB = beta blockers
CABG = coronary artery bypass graft
CAD = coronary artery disease
FFR = fractional flow reserve
IMA = internal mammary artery
LAD = left anterior descending coronary artery
LVEF = left ventricular ejection fraction
PCI = percutaneous coronary intervention
SIHD = stable ischemic heart disease

CORONARY REVASCULARIZATION IN PATIENTS WITH STABLE ISCHEMIC HEART DISEASE: APPROPRIATE USE CRITERIA (BY INDICATION)

Section 1: SIHD Without Prior CABG

The format for tables in Section 1 is similar, with separate tables for 1-, 2-, and 3-vessel disease and left main disease. The columns in each table are stratified into 2 categories. There is a single column combining patients who are asymptomatic and not receiving antianginal therapy with patients who are asymptomatic and receiving antianginal therapy. The remaining columns are devoted to patients with ischemic symptoms, with 3 separate categories: ischemic symptoms and receiving no antianginal therapy, ischemic symptoms and receiving 1 antianginal drug (beta blocker preferred), and ischemic symptoms receiving 2 or more antianginal drugs. As outlined in the SIHD guideline, in the absence of contraindications, initial therapy should be a beta blocker prescribed at a dose that reduces heart rate without excessive resting bradycardia, hypotension, or fatigue. Other antianginal drugs are then added to beta blockers depending on the individual needs of the patient until symptoms are suppressed to the satisfaction of the patient or higher doses cannot be used because of side effects. In each of the subordinate columns, the panel was asked to rate the options for revascularization, specifically PCI or CABG. As noted earlier, the rating panel was asked to rate each revascularization option independent of the other, with the intent to rate each therapy on its own merits rather than in comparison to the other option. In this construct, both revascularization options could be assigned identical ratings.

In this and subsequent tables, clinical scenarios often contain the phrase ''noninvasive testing.'' In this document, that phrase includes all forms of stress testing using either dynamic or pharmacological stress that may be coupled with various imaging tests. It also could include other imaging, such as coronary computed tomography angiography or magnetic resonance imaging, to assess myocardial viability. Some would favor the term ''functional testing,'' but the writing committee did not view this as inclusive of computed tomography or magnetic resonance imaging and thus favored the term ''noninvasive testing.'' FFR is considered as part of an invasive evaluation and is cited separately in some scenarios. An emerging technology, computed tomography-derived FFR is a combination technique that is noninvasive like computed tomography but provides FFR, which has traditionally only been an invasive test.

Table 3: One-Vessel Disease

Similar to the 2011 CABG and 2012 SIHD guidelines, this document uses proximal LAD disease as an additional anatomic discriminator for 1-vessel CAD. Although data are minimal, the writing committee felt that proximal disease of a dominant circumflex should be considered as high-risk anatomy with similar implications as proximal LAD disease, and thus, it was considered in a separate section along with proximal LAD disease.

Table 4: Two-Vessel Disease

The format of this table is similar to that for 1-vessel disease. Similar to the 2011 CABG and 2012 SIHD guidelines, this document makes a distinction regarding the presence or absence of proximal LAD disease. The writing group did not add proximal left dominant circumflex disease as an additional discriminator, because most would consider an isolated stenosis in this location to be the equivalent of 2-vessel disease (i.e., right coronary artery and circumflex disease). Following this construct, the combination of proximal LAD disease and proximal left dominant circumflex disease would be considered as 3-vessel disease and rated using the 3-vessel disease table (Table 5). In the absence of exercise data, invasive physiological testing

Table 3. One-vessel disease

Appropriate Use Score (1-9)									
One-Vessel Disease									
		Asymptomatic				**Ischemic Symptoms**			
		Not on AA Therapy or With AA Therapy		**Not on AA Therapy**		**On 1 AA Drug (BB Preferred)**		**On ≥2 AA Drugs**	
Indication		**PCI**	**CABG**	**PCI**	**CABG**	**PCI**	**CABG**	**PCI**	**CABG**
No Proximal LAD or Proximal Left Dominant LCX Involvement									
1.	■ Low-risk findings on noninvasive testing	R (2)	R (1)	R (3)	R (2)	M (4)	R (3)	A (7)	M (5)
2.	■ Intermediate- or high-risk findings on noninvasive testing	M (4)	R (3)	M (5)	M (4)	M (6)	M (4)	A (8)	M (6)
3.	■ No stress test performed or, if performed, results are indeterminate ■ FFR ≤0.80*	M (4)	R (2)	M (5)	R (3)	M (6)	M (4)	A (8)	M (6)
Proximal LAD or Proximal Left Dominant LCX Involvement Present									
4.	■ Low-risk findings on noninvasive testing	M (4)	R (3)	M (4)	M (4)	M (5)	M (5)	A (7)	A (7)
5.	■ Intermediate- or high-risk findings on noninvasive testing	M (5)	M (5)	M (6)	M (6)	A (7)	A (7)	A (8)	A (8)
6.	■ No stress test performed or, if performed, results are indeterminate ■ FFR ≤0.80	M (5)	M (5)	M (6)	M (6)	M (6)	M (6)	A (8)	A (7)

A, appropriate; *AA*, antiangina; *BB*, beta blockers; *CABG*, coronary artery bypass graft; *FFR*, fractional flow reserve; *iFR*, instant wave-free ratio; *LAD*, left anterior descending coronary artery; *LCX*, left circumflex artery; *M*, may be appropriate; *PCI*, percutaneous coronary intervention; *R*, rarely appropriate
The number in parentheses next to the rating reflects the median score for that indication
*iFR measurements with appropriate normal ranges may be substituted for FFR

of both involved vessels is included in several of the indications. To remain in this table of 2-vessel disease, such testing must be abnormal in both vessels. If this testing shows only 1 vessel to be abnormal, the patient would no longer be rated using this table, but rather would be rated in the table for 1-vessel CAD. Finally, because of the increasing body of literature that has identified diabetes as an important factor to consider when recommending revascularization, scenarios indicating the presence of diabetes are provided.

Table 5: Three-Vessel Disease

Similar to Table 4, because of the increasing body of literature that has identified diabetes as an important factor to consider when recommending revascularization, categories indicating the presence or absence of diabetes are provided among the individual indications. Stenosis complexity is also an important factor to consider in any revascularization procedure, probably more so for PCI than for CABG. The SYNTAX (Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery) trial provided a comprehensive comparison of PCI and CABG and a structure that may be helpful in formulating revascularization recommendations.[35] Factors such as vessel occlusion, bifurcation or trifurcation at branch points, ostial stenosis location, length >20 mm, tortuosity, calcification, and thrombus all add to the complexity of PCI. The presence of multiple complex features (SYNTAX score >22) is associated with more favorable outcomes with CABG. Although limitations of the SYNTAX score for certain revascularization recommendations are recognized and it may be impractical to apply this scoring system to all patients with multivessel disease, it is a reasonable surrogate for the extent and complexity of CAD and provides important information that can be helpful when making revascularization decisions.

Accordingly, in this table specifically for patients with 3-vessel disease, the rating panel was asked to consider the indications in patients with low complexity compared with those with intermediate and high complexity.

Table 6: Left Main Coronary Artery Stenosis

Literature on the treatment of significant left main disease is dominated by surgical revascularization procedures and, more recently, comparisons with PCI in some anatomic situations. There are data suggesting that stenting of the left main ostium or trunk is more

Table 4. Two-Vessel Disease

Appropriate Use Score (1-9)									
Two-Vessel Disease									
		Asymptomatic				**Ischemic Symptoms**			
		Not on AA Therapy or With AA Therapy		**Not on AA Therapy**		**On 1 AA Drug (BB Preferred)**		**On ≥2 AA Drugs**	
Indication		**PCI**	**CABG**	**PCI**	**CABG**	**PCI**	**CABG**	**PCI**	**CABG**
No Proximal LAD Involvement									
7.	■ Low-risk findings on noninvasive testing	R (3)	R (2)	M (4)	R (3)	M (5)	M (4)	A (7)	M (6)
8.	■ Intermediate- or high-risk findings on noninvasive testing	M (5)	M (4)	M (6)	M (5)	A (7)	M (6)	A (8)	A (7)
9.	■ No stress test performed or, if performed, results are indeterminate ■ FFR ≤0.80* in both vessels	M (5)	M (4)	M (6)	M (4)	A (7)	M (5)	A (8)	A (7)
Proximal LAD Involvement and No Diabetes Present									
10.	■ Low-risk findings on noninvasive testing	M (4)	M (4)	M (5)	M (5)	M (6)	M (6)	A (7)	A (7)
11.	■ Intermediate- or high-risk findings on noninvasive testing	M (6)	M (6)	A (7)	A (7)	A (7)	A (7)	A (8)	A (8)
12.	■ No stress test performed or, if performed, results are indeterminate ■ FFR ≤0.80 in both vessels	M (6)	M (6)	M (6)	M (6)	A (7)	A (7)	A (8)	A (8)
Proximal LAD Involvement With Diabetes Present									
13.	■ Low-risk findings on noninvasive testing	M (4)	M (5)	M (4)	M (6)	M (6)	A (7)	A (7)	A (8)
14.	■ Intermediate- or high-risk findings on noninvasive testing	M (5)	A (7)	M (6)	A (7)	A (7)	A (8)	A (8)	A (9)
15.	■ No stress test performed or, if performed, results are indeterminate ■ FFR ≤0.80 in both vessels*	M (5)	M (6)	M (6)	A (7)	A (7)	A (8)	A (7)	A (8)

The number in parentheses next to the rating reflects the median score for that indication
*iFR measurements with appropriate normal ranges may be substituted for FFR
A, appropriate; *AA*, antiangina; *BB*, beta blockers; *CABG*, coronary artery bypass graft; *FFR*, fractional flow reserve; *iFR*, instant wave-free ratio; *LAD*, left anterior descending coronary artery; *M*, may be appropriate; *PCI*, percutaneous coronary intervention; *R*, rarely appropriate

straightforward than treating distal bifurcation or trifurcation stenoses and is associated with a lower rate of restenosis. In comparison, left main lesion location has a negligible influence on the success and long-term results of CABG. Accordingly, there are separate rating options for ostial and midshaft left main disease and distal or bifurcation left main disease. The definition of a significant left main stenosis used herein is ≥50% narrowing by angiography. However, the angiographic assessment of the severity of left main disease has several shortcomings, and other assessments such as IVUS or FFR may be needed. For left main coronary artery stenoses, a minimum lumen diameter of <2.8 mm or a minimum lumen area of <6 mm^2 suggests a physiologically significant lesion. It has been suggested that a minimum lumen area >7.5 mm^2 suggests revascularization may be safely deferred. A minimum lumen area between 6 and 7.5 mm^2 requires further physiological assessment, such as measurement of FFR. Alternatively, FFR may be used as the first modality to assess ambiguous left main severity, and the criteria for a significant stenosis are the same as for nonleft main stenosis.[21,36,37]

Section 2: Tables 7 and 8 SIHD With Prior CABG

Patients with prior CABG surgery can present with a wide spectrum of disease progression. This includes the development of new obstructive disease in coronary arteries not bypassed in the first operation, new stenoses in existing bypass grafts, and territory previously bypassed but jeopardized again because of graft occlusion. Developing indications inclusive of all of these anatomic possibilities would be impractical. Accordingly, the writing committee adopted a more compact construct based on the presence of a significant stenosis in a bypass graft or native coronary artery supplying 1, 2, or 3 distinct vascular territories roughly corresponding to the territories of the 3 main coronary arteries. As

Table 5. Three-Vessel Disease

Appropriate Use Score (1-9)									
Three-Vessel Disease									
		Asymptomatic				**Ischemic Symptoms**			
		Not on AA Therapy or With AA Therapy		**Not on AA Therapy**		**On 1 AA Drug (BB Preferred)**		**On ≥2 AA Drugs**	
Indication		**PCI**	**CABG**	**PCI**	**CABG**	**PCI**	**CABG**	**PCI**	**CABG**
Low Disease Complexity (e.g., Focal Stenoses, SYNTAX ≤22)									
16.	■ Low-risk findings on noninvasive testing ■ No diabetes	M (4)	M (5)	M (5)	M (5)	M (6)	M (6)	A (7)	A (7)
17.	■ Intermediate- or high-risk findings on noninvasive testing ■ No diabetes	M (6)	A (7)	A (7)	A (7)	A (7)	A (8)	A (8)	A (8)
18.	■ Low-risk findings on noninvasive testing ■ Diabetes present	M (4)	M (6)	M (5)	M (6)	M (6)	A (7)	A (7)	A (8)
19.	■ Intermediate- or high-risk findings on noninvasive testing ■ Diabetes present	M (6)	A (7)	M (6)	A (8)	A (7)	A (8)	A (7)	A (9)
Intermediate or High Disease Complexity (e.g. Multiple Features of Complexity as Noted Previously, SYNTAX >22)									
20.	■ Low-risk findings on noninvasive testing ■ No diabetes	M (4)	M (6)	M (4)	A (7)	M (5)	A (7)	M (6)	A (8)
21.	■ Intermediate- or high-risk findings on noninvasive testing ■ No diabetes	M (5)	A (7)	M (6)	A (7)	M (6)	A (8)	M (6)	A (9)
22.	■ Low-risk findings on noninvasive testing ■ Diabetes present	M (4)	A (7)	M (4)	A (7)	M (5)	A (8)	M (6)	A (9)
23.	■ Intermediate- or high-risk findings on noninvasive testing ■ Diabetes present	M (4)	A (8)	M (5)	A (8)	M (5)	A (8)	M (6)	A (9)

The number in parentheses next to the rating reflects the median score for that indication
A, appropriate; *AA*, antiangina; *BB*, beta blockers; *CABG*, coronary artery bypass graft; *M*, may be appropriate; *PCI*, percutaneous coronary intervention; *SYNTAX*, synergy between PCI with taxus and cardiac surgery trial

in patients without prior CABG, the indications included an assessment of risk based on noninvasive testing (low versus intermediate or high risk).

Evaluation of the severity and physiological significance of a stenosis in saphenous vein grafts (SVG) can be particularly challenging because of the usual marked size difference between the SVG and native artery. Although FFR measurements are well-validated in native vessels, data on the use of FFR in vein grafts are limited.[38] After CABG surgery, the bypass conduit should act in a similar fashion to the native, low-resistance epicardial vessel. However, the assessment of ischemia due to a stenosis in a vein graft is complicated by several features, which include: 1) the potential for competing flow (and pressure) from both the native and conduit vessels; 2) the presence of collaterals from longstanding native coronary occlusion; and 3) the potential for microvascular abnormalities due to ischemic fibrosis and scarring, pre-existing or bypass surgery-related myocardial infarction, or chronic low-flow ischemia. Despite these complicating features, the theory of FFR should apply equally to both a lesion in an SVG to the right coronary artery feeding a normal myocardial bed and a lesion in the native right coronary. However, if the native and collateral supply are sufficiently large, the FFR across an SVG stenosis could be normal. FFR measurements may be most useful in the setting of an occluded bypass graft to a native artery with an intermediate-severity stenosis. FFR measurements in bypass grafts are less well-validated and should thus be interpreted with caution.

Two tables are presented for the rating of patients with prior CABG depending on the patency of an existing internal mammary artery (IMA) graft. IMAs have a greater long-term patency rate than SVGs—typically >90% after 10 years.[39,40] Accordingly, use of the IMA as a conduit in CABG surgery has steadily increased. Current use is 98%, as reported in the Society of Thoracic Surgeons national database, and use of the IMA as a conduit is 1 of the quality metrics in their composite score. Because of the current high use of the IMA, the writing committee felt there were too few patients to consider a separate category

Table 6. Left main coronary artery stenosis

Appropriate Use Score (1–9)									
Left Main Disease									
		Asymptomatic				**Ischemic Symptoms**			
		Not on AA Therapy or With AA Therapy		**Not on AA Therapy**		**On 1 AA Drug (BB Preferred)**		**On ≥2 AA Drugs**	
Indication		**PCI**	**CABG**	**PCI**	**CABG**	**PCI**	**CABG**	**PCI**	**CABG**
24.	■ Isolated LMCA disease ■ Ostial or midshaft stenosis	M (6)	A (8)	A (7)	A (8)	A (7)	A (9)	A (7)	A (9)
25.	■ Isolated LMCA disease ■ Bifurcation involvement	M (5)	A (8)	M (5)	A (8)	M (5)	A (9)	M (6)	A (9)
26.	■ LMCA disease ■ Ostial or midshaft stenosis ■ Concurrent multivessel disease ■ Low disease burden (e.g., 1–2 additional focal stenoses, SYNTAX score ≤22)	M (6)	A (8)	M (6)	A (9)	A (7)	A (9)	A (7)	A (9)
27.	■ Ostial or midshaft stenosis ■ Concurrent multivessel disease ■ Intermediate or high disease burden (e.g., 1–2 additional bifurcation stenosis, long stenoses, SYNTAX score >22)	M (4)	A (9)	M (4)	A (9)	M (4)	A (9)	M (4)	A (9)
28.	■ LMCA disease ■ Bifurcation involvement ■ Low disease burden in other vessels (e.g., 1–2 additional focal stenosis, SYNTAX score ≤22)	M (4)	A (8)	M (5)	A (8)	M (5)	A (9)	M (6)	A (9)
29.	■ LMCA disease ■ Bifurcation involvement ■ Intermediate or high disease burden in other vessels (e.g., 1–2 additional bifurcation stenosis, long stenoses, SYNTAX score >22)	R (3)	A (8)	R (3)	A (9)	R (3)	A (9)	R (3)	A (9)

The number in parentheses next to the rating reflects the median score for that indication
A, appropriate; *AA*, antiangina; *BB*, beta blockers; *CABG*, coronary artery bypass graft; *FFR*, fractional flow reserve; *iFR*, instant wave-free ratio; *LAD*, left anterior descending coronary artery; *M*, may be appropriate; *PCI*, percutaneous coronary intervention; *R*, rarely appropriate

consisting of patients who only had SVGs used in their first operation, although a few such patients may exist. Moreover, the writing committee did not develop any scenarios where the initial operation consisted of only bypass grafts to the circumflex and right coronary artery in the absence of LAD disease. The patency and longevity of the IMA as a bypass graft was felt by the writing committee to be an important decision point in the indication development, as many cardiovascular surgeons are hesitant to perform a second bypass operation in the presence of a patent and fully functional IMA graft, especially to the LAD. The path of the IMA, particularly if it courses medially or is adherent to the back of the sternum, may be at greater risk during sternal re-entry, with adverse consequences even if the IMA-grafted vessel is regrafted. For Table 7., it is assumed that the LAD was significantly diseased at the time of the original operation. Therefore, if the IMA to the LAD is no longer patent or is severely diseased, it is assumed that the native LAD is also severely diseased or occluded.

Section 3: Table 9 SIHD Undergoing Procedures for Which Coronary Revascularization May Be Considered

In an effort to capture common clinical scenarios that are not well-represented in guidelines, the writing group developed indications for pre-operative revascularization in patients being evaluated for renal transplantation or structural heart procedures. The writing committee recognized that pre-operative revascularization is sometimes requested before transplantation of other organs, but there is insufficient experience or data from controlled studies upon which to develop meaningful scenarios. These scenarios do not capture all possible clinical situations, but were felt to capture the majority of common clinical situations. If patients have an acute coronary syndrome, the writing group felt they should be rated according to the AUC for acute coronary syndrome. For many of these patients, symptoms may be difficult to attribute to myocardial ischemia; thus, the indications used in this table provide

Table 7. IMA to LAD patent and without significant stenoses

Appropriate Use Score (1-9)		Asymptomatic				Ischemic Symptoms			
		Not on AA Therapy or With AA Therapy		Not on AA Therapy		On 1 AA Drug (BB Preferred)		On ≥2 AA Drugs	
Indication		PCI	CABG	PCI	CABG	PCI	CABG	PCI	CABG
Stenosis Supplying 1 Territory Disease (Bypass Graft or Native Artery) to Territory Other Than Anterior									
30.	■ Low-risk findings on noninvasive testing	R (3)	R (1)	R (3)	R (2)	M (6)	R (3)	A (7)	M (4)
31.	■ Intermediate- or high-risk findings on noninvasive testing	M (5)	R (3)	M (5)	R (3)	A (7)	M (4)	A (8)	M (5)
32.	■ No stress test performed or, if performed, the results are indeterminate ■ FFR of stenosis ≤0.80*	M (4)	R (3)	M (4)	R (3)	M (6)	M (4)	A (8)	M (5)
Stenoses Supplying 2 Territories (Bypass Graft or Native Artery, Either 2 Separate Vessels or Sequential Graft Supplying 2 Territories) Not Including Anterior Territory									
33.	■ Low-risk findings on noninvasive testing	R (3)	R (2)	M (4)	R (3)	M (6)	R (3)	A (7)	M (5)
34.	■ Intermediate- or high-risk findings on noninvasive testing	M (5)	R (3)	M (5)	M (4)	A (7)	M (5)	A (8)	M (6)

The number in parentheses next to the rating reflects the median score for that indication
*iFR measurements with appropriate normal ranges may be substituted for FFR
A, appropriate; *AA*, antiangina; *BB*, beta blockers; *CABG*, coronary artery bypass graft; *FFR*, fractional flow reserve; *iFR*, instant wave-free ratio; *IMA*, internal mammary artery; *LAD*, left anterior descending coronary artery; *M*, may be appropriate; *PCI*, percutaneous coronary intervention; *R*, rarely appropriate

only anatomic and noninvasive test findings for review. Note that for patients being evaluated before a percutaneous valve procedure, the option for CABG surgery is blocked out, as it is assumed such patients have clinical factors making their risk of surgery prohibitively high.

DISCUSSION

The AUC are intended to inform clinicians, patients, and health policy makers about the reasonable use of technologies to help improve patient symptoms and health outcomes. Since 2005, the American College of Cardiology, along with its professional partners, has worked to provide criteria for both invasive and noninvasive testing and selected treatments, with the intention of further expanding the AUC portfolio.

The 2017 Appropriate Use Criteria for Revascularization in Patients With Stable Ischemic Heart Disease is the culmination of approximately 2 years of review and revision to the existing AUC. In response to comments from multiple stakeholders, the current AUC has several important changes.[41] First, this document will use the new terms ''appropriate care,'' ''may be appropriate care,'' and ''rarely appropriate care,'' which were described in the updated AUC methodology paper.[2] Second, the composition of the rating panel was changed slightly to include 5 cardiac surgeons, 5 interventional cardiologists, 6 cardiologists not directly involved with performing revascularization, and 1 outcomes researcher. Third, the new criteria stratify symptoms into 2 general groups—asymptomatic and ischemic symptoms—to be inclusive of the spectrum of complaints that may occur from myocardial ischemia. Furthermore, because of the variety of symptoms that may indicate myocardial ischemia, individual patient variation in how they are described, and observer variability in the assessment of symptom severity, the writing group chose to abandon the Canadian Cardiac Society classification. However, the current criteria continue to emphasize the use of more objective measures of ischemia within indications to stratify patients into low-risk or intermediate-/high-risk findings, as described in the SIHD guideline. Fourth, the scenarios expand the use of intracoronary physiological testing, mainly with FFR. Fifth, the structure of the AUC tables concerning the use of antianginal therapy has changed to reflect typical practice patterns rating patients on the basis of no antianginal therapy, use of 1 antianginal drug, or use of 2 or more antianginal drugs. As in earlier documents, it is assumed that all patients are being treated with guideline-directed medical therapies to reduce risk. Finally, in an effort to capture patients who have not previously been categorized, the current AUC also rate coronary revascularization in patients being considered for renal transplantation and percutaneous valve procedures.

Review of the ratings demonstrate some themes around revascularization of patients with SIHD that are consistent with existing clinical practice guidelines. In general, in patients with a low burden of coronary

Table 8. IMA to LAD not patent

Appropriate Use Score (1-9)		Asymptomatic				Ischemic Symptoms			
		Not on AA Therapy or With AA Therapy		Not on AA Therapy		On 1 AA Drug (BB Preferred)		On ≥2 AA Drugs	
Indication		PCI	CABG	PCI	CABG	PCI	CABG	PCI	CABG
Stenosis Supplying 1-Territory Disease (Bypass Graft or Native Artery)-Anterior (LAD) Territory									
35.	■ Low-risk findings on noninvasive testing	M (4)	R (3)	M (5)	R (3)	M (6)	M (4)	A (7)	M (5)
36.	■ Intermediate- or high-risk findings on noninvasive testing	M (6)	M (4)	M (6)	M (4)	A (7)	M (5)	A (8)	M (6)
37.	■ No stress test performed or, if performed, the results are indeterminate ■ FFR of stenosis ≤0.80*	M (5)	M (4)	M (6)	M (4)	A (7)	M (5)	A (8)	M (6)
Stenoses Supplying 2 Territories (Bypass Graft or Native Artery, Either 2 Separate Vessels or Sequential Graft Supplying 2 Territories) LAD Plus Other Territory									
38.	■ Low-risk findings on noninvasive testing	M (5)	M (4)	M (6)	M (4)	A (7)	M (5)	A (7)	M (6)
39.	■ Intermediate- or high-risk findings on noninvasive testing	M (6)	M (5)	A (7)	M (6)	A (7)	A (7)	A (8)	A (8)
Stenoses Supplying 3 Territories (Bypass Graft or Native Arteries, Separate Vessels, Sequential Grafts, or Combination Thereof) LAD Plus 2 Other Territories									
40.	■ Low-risk findings on noninvasive testing	M (5)	M (5)	M (6)	M (5)	M (6)	M (6)	A (7)	A (7)
41.	■ Intermediate- or high-risk findings on noninvasive testing	A (7)	A (7)	A (7)	A (7)	A (7)	A (7)	A (8)	A (8)

The number in parentheses next to the rating reflects the median score for that indication
*iFR measurements with appropriate normal ranges may be substituted for FFR
A, appropriate; *AA*, antiangina; *BB*, beta blockers; *CABG*, coronary artery bypass graft; *FFR*, fractional flow reserve; *iFR*, instant wave-free ratio; *IMA*, internal mammary artery; *LAD*, left anterior descending coronary artery; *M*, may be appropriate; *PCI*, percutaneous coronary intervention; *R*, rarely appropriate

disease (e.g., single-vessel disease), low-risk findings on noninvasive testing, and/or no antianginal therapy, revascularization by PCI or CABG surgery for care is felt to be rarely appropriate as the initial step. As disease burden progresses through 2-vessel to 3-vessel and left main disease, revascularization by PCI or CABG frequently becomes rated as ''may be appropriate care'' or ''appropriate care,'' with CABG surgery consistently rated as ''appropriate care'' for intermediate or high disease complexity (SYNTAX ≥22) even in patients with ischemic symptoms who are not on antianginal therapy. Of note, CABG surgery was consistently rated as ''appropriate care'' and PCI as ''rarely appropriate care'' for left main bifurcation disease with intermediate or high disease burden in other vessels.

Repeat CABG surgery was felt to be rarely appropriate in patients with a functional patent IMA to the LAD in all but 1 indication, with both PCI and CABG being rated as either ''may be appropriate care'' or ''appropriate care'' in the other indications, reflecting the complex and individualized decision making required in these patients. With the exception of a few specific scenarios in asymptomatic patients with a low disease burden, revascularization options were considered as ''may be appropriate care'' or ''appropriate care'' options. Although not directly rated, the use of fractional flow reserve for evaluation of renal transplant patients may be considered and will be addressed in future revascularization documents. Revascularization by PCI was considered appropriate care for the majority of patients being evaluated before a percutaneous valve procedure.

Application of Criteria

There are many potential applications for AUC, including their adoption by Centers for Medicare & Medicaid Services regulators as a means of evaluating care. Clinicians can use the ratings for decision support or as an educational tool when considering the need for revascularization. Moreover, these criteria can be used to facilitate discussions with patients and/or referring physicians about the need for revascularization. The original intent of the AUC was to provide a tool to identify patterns of care, including both the overuse and underuse of various services. In fact, some of the initial publications related to AUC identified underuse and the consequences of underuse rather than overuse of services.[42,43] Facilities have used these criteria to design protocols to facilitate the appropriate care of patients. Some payers have adopted the AUC for use in the preauthorization of procedures or retrospectively for

Table 9. Stable ischemic heart disease undergoing procedures for which coronary revascularization may be considered

Appropriate Use Score (1–9)									
		Asymptomatic				Ischemic Symptoms			
		Not on AA Therapy or With AA Therapy		Not on AA Therapy		On 1 AA Drug (BB Preferred)		On ≥2 AA Drugs	
Indication		PCI	CABG	PCI	CABG	PCI	CABG	PCI	CABG
Patients Undergoing Renal Transplantation, No Diabetes									
42.	■ One- or two-vessel CAD, no proximal LAD involvement, with low-risk noninvasive findings	R (3)	R (2)	M (4)	R (3)	M (6)	M (4)	A (7)	M (5)
43.	■ One- or two-vessel CAD, no proximal LAD involvement, with intermediate- or high-risk noninvasive findings	M (5)	M (4)	M (6)	M (4)	A (7)	M (5)	A (8)	M (6)
44.	■ One- or two-vessel CAD, including proximal LAD, with low-risk noninvasive findings	M (5)	M (4)	M (6)	M (5)	M (6)	M (6)	A (8)	A (7)
45.	■ One- or two-vessel CAD, including proximal LAD, with intermediate- or high-risk noninvasive findings	M (6)	M (6)	A (7)	A (7)	A (7)	A (7)	A (8)	A (8)
46.	■ Left main and/or three-vessel disease, with intermediate- or high-risk noninvasive findings (e.g., SYNTAX ≤22)	M (6)	A (7)	A (7)	A (7)	A (7)	A (7)	A (8)	A (8)
47.	■ Left main and/or three-vessel disease, with intermediate- or high-risk noninvasive findings (e.g., SYNTAX >22)	M (5)	A (7)	M (6)	A (8)	M (6)	A (8)	M (6)	A (9)
Patients Undergoing Renal Transplantation, Diabetes Present									
48.	■ One- or two-vessel CAD, no proximal LAD involvement, with low-risk noninvasive findings	R (3)	R (3)	M (4)	R (3)	M (5)	M (4)	A (7)	M (6)
49.	■ One- or two-vessel CAD, no proximal LAD involvement, with intermediate- or high-risk noninvasive findings	M (5)	M (4)	M (5)	M (4)	M (6)	M (5)	A (7)	A (7)
50.	■ One- or two-vessel CAD, including proximal LAD, with low-risk noninvasive findings	M (5)	M (5)	M (5)	M (6)	M (5)	A (7)	A (7)	A (7)
51.	■ One- or two-vessel CAD, including proximal LAD, with intermediate- or high-risk noninvasive findings	M (6)	M (6)	M (6)	A (7)	M (6)	A (7)	A (7)	A (8)
52.	■ Left main and/or three-vessel disease, with intermediate- or high-risk noninvasive findings (e.g., SYNTAX ≤22)	M (6)	A (8)	M (6)	A (8)	M (6)	A (8)	A (7)	A (9)
53.	■ Left main and/or three-vessel disease, with intermediate- or high-risk noninvasive findings (e.g., SYNTAX >22)	M (5)	A (8)	M (5)	A (8)	M (5)	A (9)	M (5)	A (9)
Patient Who Will Undergo a Percutaneous Valve Procedure (TAVR, MitraClip, Others)									
54.	■ One- or two-vessel CAD, no proximal LAD involvement, with low-risk noninvasive findings	M (4)		M (4)		M (6)		A (8)	
55.	■ One- or two-vessel CAD, no proximal LAD involvement, with intermediate- or high-risk noninvasive findings	A (7)		A (7)		A (7)		A (8)	
56.	■ One- or two-vessel CAD, including proximal LAD, with low-risk noninvasive findings	M (6)		M (6)		A (7)		A (8)	
57.	■ One- or two-vessel CAD, including proximal LAD, with intermediate- or high-risk noninvasive findings	A (7)		A (7)		A (8)		A (9)	
58.	■ Left main and/or three-vessel disease, with intermediate- or high-risk noninvasive findings (e.g., SYNTAX ≤22)	A (8)		A (8)		A (8)		A (9)	
59.	■ Left main and/or three-vessel disease, with intermediate- or high-risk noninvasive findings (e.g., SYNTAX >22)	A (7)		A (7)		A (8)		A (8)	

The number in parentheses next to the rating reflects the median score for that indication
A, appropriate; *AA*, antiangina; *BB*, beta blockers; *CABG*, coronary artery bypass graft; *CAD*, coronary artery disease; *LAD*, left anterior descending coronary artery; *M*, may be appropriate; *PCI*, percutaneous coronary intervention; *R*, rarely appropriate; *SYNTAX*, Synergy between PCI with Taxus and Cardiac Surgery trial; *TAVR*, transcatheter aortic value replacement

quality reports. Although the AUC were never intended to determine payment in individual patients, some payers have adopted the AUC for this purpose. The desire of payers to control costs is understood, but it should be in the context of developing rational payment management strategies to ensure their members receive necessary, beneficial, and cost-effective cardiovascular care, rather than for other purposes. It is expected that services performed for ''appropriate'' or ''may be appropriate'' indications will receive reimbursement. In contrast, services performed for ''rarely appropriate'' indications should be justified by additional documentation to justify payment 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 a rating of ''may be appropriate'' is justification to deny reimbursement for revascularization. Rather, ''may be appropriate'' ratings are those in which the available data vary and many other factors exist that may affect the decision to perform or not perform revascularization. The opinions of the technical panel often varied for these indications, reflecting that additional research is needed.

The writing group recognizes the need to align the collection of clinical data required for the determination of appropriate use with appropriate methods to reduce the burden of data collection. To this end, the NCDR CathPCI Registry group has been engaged in a parallel process to ensure that needed data elements are incorporated into the Registry. The criteria will also be evaluated for collection by the Society for Thoracic Surgeons registry. Incorporating fields to identify patients who are not felt to be candidates for PCI or

CABG surgery has been suggested to ensure proper mapping of the AUC in the course of medical decision making. The writing committee believes the key step to ensuring that the AUC are iterated and continually improved is the use of a feedback cycle of data between current clinical practice and the Registry. The writing group also believes that the mapping of the data elements on the NCDR CathPCI Registry data collection from the AUC should be transparent for all providers to review and implement local systems of care.

In conclusion, this document represents the current understanding of the clinical benefit of coronary revascularization with respect to health outcomes and survival. These criteria have been developed through the AUC process and alignment with the evidence and recommendations from clinical practice guidelines. This is intended to provide a practical guide to clinicians and patients when considering revascularization. As with all AUC, some of these ratings will require research and further evaluation to provide the greatest information and benefit to clinical decision making. We anticipate that the utility and ability of these criteria to improve the quality of care will be measured by the overall use and adoption of the criteria. With each update, the AUC for coronary revascularization in SIHD have become more refined and specific, while areas for continued focus and research have been identified.

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APPENDIX 1: ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS 2017 APPROPRIATE USE CRITERIA FOR CORONARY REVASCULARIZATION IN PATIENTS WITH STABLE ISCHEMIC HEART DISEASE: PARTICIPANTS

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APPENDIX 2: 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 rating 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 rating panel at the face-to-face meeting, and updated and reviewed as necessary. The following is a table of relevant disclosures by the rating panel and oversight working group members. In addition, to ensure complete transparency, a full list of disclosure information—including relationships not pertinent to this document—is available in the Online Appendix.

Appropriate use criteria for coronary revascularization in patients with stable ischemic heart disease: members of the writing group, rating panel, indication reviewers, and AUC task force—relationships with industry and other entities (relevant)

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Participant	Employment	Consultant	Speakers bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
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David J. Maron	Stanford University School of Medicine—Clinical Professor of Medicine, Cardiovascular, Director, Preventive Cardiology	None	None	None	None	None	None
Peter K. Smith	Cardiovascular and Thoracic Surgery, Duke University—Professor of Surgery, Division Chief	None	None	None	None	None	None
Rating panel							
James C. Blankenship	Geisinger Medical Center, Division of Cardiology—Staff Physician, Director, Cardiac Catheterization Laboratory	None	None	None	■ Abbott Vascular† ■ AstraZeneca† ■ Boston Scientific† ■ GlaxoSmithKline† ■ Hamilton Health Services† ■ Medinal LTD* ■ Orexigen Therapeutics/ Takeda† ■ Stentys, Inc.† ■ Takeda Pharmaceuticals	None	None

Participant	Employment	Consultant	Speakers bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
Alfred A. Bove	Temple University, Lewis Katz School of Medicine, Heart and Vascular—Professor Emeritus	None	None	None	■ Merck Schering-Plough†	None	None
Steven M. Bradley	VA Eastern Colorado Health Care System, Division of Cardiology at the University of Colorado—Staff Cardiologist, Assistant Professor of Medicine	None	None	None	None	None	None
Larry S. Dean	Medicine Regional Heart Center University of Washington School of Medicine—Professor of Medicine and Surgery, Director	■ Philips Medical*	None	None	■ Edwards Lifesciences*	None	None
Peter L. Duffy	First Health of the Carolinas, Reid Heart Institute/Moore Regional Hospital—Director of Quality for the Cardiovascular Service Line	None	■ Volcano Corp*	None	None	None	None
T. Bruce Ferguson, Jr.	East Carolina Heart Institute, East Carolina University, Department of Cardiovascular Sciences, Cardiothoracic Surgery—Professor of Thoracic Surgery	None	None	RFPi†	■ Novadaq Technologies*	None	None
Frederick L. Grover	University of Colorado, Department of Cardiothoracic Surgery—Professor of Cardiothoracic Surgery	■ Somalution	None	None	None	None	None

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Robert A. Guyton	Emory University School of Medicine, Division of Cardiothoracic Surgery, Department of Surgery, Thoracic Surgery Residency Program—Chief of Cardiothoracic Surgery, Professor of Surgery Director	■ Medtronic*	None	None	None	None	None
Mark A. Hlatky	Stanford University School of Medicine, Cardiovascular Medicine, Health Services Research—Professor of Heath Research and Policy, Professor of Medicine	None	None	None	None	■ Sanofi-Aventis	None
Harold L. Lazar	Boston University School of Medicine, Cardiothoracic Research Program—Director Professor of Cardiothoracic Surgery	None	None	None	None	None	None
Vera H. Rigolin	Northwestern University Feinberg School of Medicine, Cardiology—Professor	None	None	None	None	■ Pfizer*	None
Geoffrey A. Rose	Division of Cardiology, Sanger Heart and Vascular Institute—Chief	None	None	None	None	■ Medtronic	None

Participant	Employment	Consultant	Speakers bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
Richard J. Shemin	Ronald Reagan UCLA Medical Center, Cardiovascular Center—Director of Cardiac Quality, Robert and Kelly Day Professor, Chief of Cardiothoracic Surgery, Executive Vice Chair of Surgery	■ Edwards Lifesciences ■ Sorin Group	None	None	None	None	None
Jacqueline E. Tamis-Holland	Saint Luke's Hospital, Icahn School of Medicine at Mount Sinai Hospital Mount Sinai—Director, Women's Heart NY, Assistant Professor of Medicine, Director, Interventional Cardiology Fellowship	None	None	None	None	None	None
Carl L. Tommaso	Rush Medical College in Chicago, Skokie Illinois Hospital, part of the Northshore University Health System—Director of the Cardiac Catheterization Laboratory, Associate Professor of Medicine	None	None	None	None	None	None
L. Samuel Wann	Columbia St. Mary's Healthcare—Clinical Cardiologist, Medical Director, Heart Failure Program	■ United Healthcare	None	None	None	None	None
John B. Wong	Tufts University School of Medicine—Chief, Division of Clinical Decision Making, Primary Care Physician, Principal Investigator, Institute for Clinical Research and Health Policy Studies, Professor	None	None	None	None	None	None

Participant	Employment	Consultant	Speakers bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
Reviewers							
Jeffrey L. Anderson	Intermountain Medical Center—Associate Chief of Cardiology	■ Medicines Company ■ Sanofi-Aventis	None	None	None	None	None
Jeffrey A. Brinker	Johns Hopkins Hospital—Professor of Medicine	None	None	None	None	None	None
Alexandru I. Costea	University of Cincinnati Medical Center—Associate Professor	None	None	None	None	■ Boston Scientific†	None
Ali E. Denktas	Baylor College of Medicine—Assistant Professor	None	None	None	■ AstraZeneca ■ Edwards Lifesciences	None	None
Lloyd W. Klein	Melrose Park—Professor of Medicine	None	None	None	None	None	None
Frederick G. Kushner	Tulane University Medical Center, Heart Clinic of Louisiana—Clinical Professor, Medical Director	None	None	None	None	None	None
Glenn N. Levine	Baylor College of Medicine, Cardiology—Professor	None	None	None	None	None	None
David J. Maron	Stanford University School of Medicine—Professor of Medicine and Emergency Medicine	None	None	None	None	None	None

Participant	Employment	Consultant	Speakers bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
James B. McClurken	Temple University, School of Medicine, Richard A Reif Heart Institute, Doylestown Hospital—Director of Thoracic Surgery, Professor of Surgery Emeritus	None	None	None	None	None	None
Robert N. Piana	Vanderbilt University Medical Center—Professor of Medicine, Cardiology	■ Axio Research ■ Harvard Clinical Research Institute ■ W.L. Gore & Associates, Inc.	None	None	None	None	None
John A. Spertus	Washington University School of Medicine—Adjunct Professor of Medicine	■ Amgen ■ Bayer Healthcare Pharmaceuticals ■ Janssen ■ Novartis ■ Regeneron	None	■ Health Outcomes Sciences	None	None	None
Raymond F. Stainback	Texas Heart Institute at Baylor St. Luke's Medical Center, Non-Invasive Cardiology—Medical Director	None	None	None	None	None	None
Robert C. Stoler	Cardiology Consultants of Texas—Director of Cardiac Catheterization Laboratory	■ Boston Scientific ■ Medtronic	None	None	None	None	None
Todd C. Villines	Cardiology Service at Walter Reed Army Medical Center—Co-Director of Cardiovascular Computed Tomography and Assistant Chief	■ Boehringer Ingelheim Pharmaceutical*	None	None	None	None	None

Participant	Employment	Consultant	Speakers bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
David H. Wiener	Jefferson Medical College, Jefferson Heart Institute—Professor of Medicine	None	None	None	None	None	None
Appropriate use criteria task force							
Steven R. Bailey	University of Texas Health Sciences Center—Chair, Division of Cardiology, Professor of Medicine and Radiology, Janey Briscoe Distinguished Chair	None	None	None	None	None	None
Nicole Bhave	University of Michigan Cardiovascular Center, Department of Internal Medicine, Division of Cardiovascular Medicine—Clinical Assistant Professor	None	None	None	None	None	None
Alan S. Brown	Midwest Heart Disease Prevention Center, Advocate Lutheran General Hospital—Director, Division of Cardiology—Medical Director	None	None	None	None	None	None
Stacie L. Daugherty	University of Colorado School of Medicine, Division of Cardiology, Department of Medicine—Associate Professor	None	None	None	None	None	None
Gregory J. Dehmer	Baylor Scott & White, Central Texas Division, Cardiovascular Services Health—Medical Director	None	None	None	None	None	None

Participant	Employment	Consultant	Speakers bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
Milind Y. Desai	Cleveland Clinic, Clinical Investigations, Heart and Vascular Institute—Associate Director	None	None	None	None	None	None
John U. Doherty	Thomas Jefferson University, Jefferson Medical College—Professor of Medicine	None	None	None	None	None	None
Claire Duvernoy	University of Michigan Health System, Division of Cardiology—Cardiology Section Chief	None	None	None	None	None	None
Linda D. Gillam	Morristown Medical Center, Department of Cardiovascular Medicine—Chair	■ Edwards Lifesciences* ■ Medtronic†	None	None	None	None	None
Robert C. Hendel	Miami University School of Medicine, Division of Cardiology—Director of Cardiac Imaging and Outpatient Services	None	None	None	None	None	None
Christopher M. Kramer	University of Virginia Health System—Ruth C. Heede Professor of Cardiology & Radiology, Director, Cardiovascular Imaging Center	None	None	None	None	None	None
Bruce D. Lindsay	Cleveland Clinic Foundation of Cardiovascular Medicine—Professor of Cardiology	None	None	None	None	None	None

Participant	Employment	Consultant	Speakers bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
Warren J. Manning	Beth Israel Deaconess Medical Center, Division of Cardiology—Professor of Medicine and Radiology	■ Merck	None	None	■ Philips Medical Systems*	None	None
Manesh R. Patel	Duke University Medical Center, Division of Cardiology—Assistant Professor of Medicine	None	None	None	None	None	None
Ritu Sachdeva	Emory University School of Medicine, Children's Health Care of Atlanta, Sibley Heart Center Cardiology, Division of Pediatric Cardiology, Department of Pediatrics—Associate Professor	None	None	None	None	None	None
L. Samuel Wann	Columbia St. Mary's Healthcare—Staff Cardiologist	None	None	None	None	None	None
David Winchester	University of Florida, Division of Cardiology—Assistant Professor of Medicine	None	None	None	None	None	None
Joseph M. Allen	American College of Cardiology—Team Leader, Clinical Policy and Pathways	None	None	None	None	None	None

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*Significant relationship

† No financial benefit

ACC, American College of Cardiology; *AUC*, appropriate use criteria

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