ACCF/ASNC/ACR/AHA/ASE/SCCT/SCMR/SNM 2009 Appropriate Use Criteria for Cardiac Radionuclide Imaging: A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the American Society of Nuclear Cardiology, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the Society of Cardiovascular Computed Tomography, the Society for Cardiovascular Magnetic Resonance, and the Society of Nuclear Medicine Endorsed by the American College of Emergency Physicians

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APPROPRIATE USE CRITERIA

ACCF/ASNC/ACR/AHA/ASE/SCCT/SCMR/SNM 2009 Appropriate Use Criteria for Cardiac Radionuclide Imaging

A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the American Society of Nuclear Cardiology, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the Society of Cardiovascular Computed Tomography, the Society for Cardiovascular Magnetic Resonance, and the Society of Nuclear Medicine

Endorsed by the American College of Emergency Physicians

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Abstract

The American College of Cardiology Foundation (ACCF), along with key specialty and subspecialty societies, conducted an appropriate use review of common clinical scenarios where cardiac radionuclide imaging (RNI) is frequently considered. This document is a revision of the original Single-Photon Emission Computed Tomography Myocardial Perfusion Imaging (SPECT MPI) Appropriateness Criteria (1), published 4 years earlier, written to reflect changes in test utilization and new clinical data, and to clarify RNI use where omissions or lack of clarity existed in the original criteria. This is in keeping with the commitment to revise and refine appropriate use criteria (AUC) on a frequent basis.

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

In general, use of cardiac RNI for diagnosis and risk assessment in intermediate- and high-risk patients with coronary artery disease (CAD) was viewed favorably, while testing in low-risk patients, routine repeat testing, and general screening in certain clinical scenarios were viewed less favorably. Additionally, use for perioperative testing was found to be inappropriate except for high selected groups of patients. It is anticipated that these results will have a significant impact on physician decision making, test performance, and reimbursement policy, and will help guide future research.

Preface

In an effort to respond to the need for the rational use of imaging services in the delivery of high quality care, the ACCF has undertaken a process to determine the appro-

priate use of cardiovascular imaging for selected patient indications.

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

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

The ACCF AUC process itself is also evolving. In the current iteration, technical panel members were asked to rate indications for cardiac RNI in a manner independent and irrespective of the prior published ACCF ratings for SPECT MPI (1) as well as the prior ACCF ratings for similar diagnostic stress imaging modalities, such as stress echocardiography (2), cardiac computed tomography, or cardiac magnetic resonance (3). Given the iterative nature of the process, readers are counseled not to compare too closely individual appropriate use ratings among modalities rated at different times over the past 2 years. Since this process is iterative and evolving, readers are counseled that individual appropriate use ratings among modalities rated at different times over the past 2 years may not be consistent. A comparative evaluation of the appropriate use of multiple imaging techniques will be undertaken in the near future to assess the relative strengths of each modality for various clinical scenarios.

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

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1. Introduction

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

All prior AUC publications from the ACCF and collaborating organizations have reflected an ongoing effort to critically and systematically create, review, and categorize the appropriate use of certain cardiovascular diagnostic tests. The American College of Cardiology recognizes the importance of revising these criteria in a timely manner in order to provide the cardiovascular community with the most accurate indications. This document presents the first attempt to update an existing AUC document, the 2005 published ACCF/ASNC Appropriateness Criteria for Single-Photon Emission Computed Tomography Myocardial Perfusion Imaging (SPECT MPI) (1). Clinicians, payers, and patients are interested in the specific benefits of cardiac RNI. Importantly, inappropriate use of cardiac RNI may be potentially harmful to patients and generate unwarranted costs to the healthcare system, whereas appropriate procedures should likely improve patients' clinical outcomes. This is a critical shift since the intent is for the potential benefits and risks of the treatment to be explicitly considered, rather than just the potential usefulness of a diagnostic test as a prelude to further treatment. This document presents the results of this effort, but it is critical to understand the background and scope of this document before interpreting the rating tables.

2. Methods

The indications included in this publication are purposefully broad, and comprise a wide array of cardiovascular signs and

symptoms as well as clinical judgment as to the likelihood of cardiovascular findings.

A detailed description of the methods used for ranking the selected clinical indications is outlined in Appendix B and is also found more generally in a previous publication entitled, "ACCF Proposed Method for Evaluating the Appropriateness of Cardiovascular Imaging" (4). Briefly, this process combines evidence-based medicine and practice experience by engaging a technical panel in a modified Delphi exercise. Since the original SPECT document (1) and methods paper (4) were published, several important processes have been put in place to further enhance this process. They include convening a formal writing group with diverse expertise in imaging, circulating the indications for external review prior to rating by the technical panel, and ensuring appropriate balance of the technical panel, a standardized rating package, and formal roles for facilitating panel interaction at the face-to-face meeting. These changes are detailed in a separate manuscript, which is in preparation.

The panel first rated indications independently. Then the panel was convened for a face-to-face meeting for discussion of each indication. At this meeting, panel members were provided with their scores and a blinded summary of their peers' scores. After the consensus meeting, panel members were then asked to independently provide their final scores for each indication.

While panel members were not provided explicit cost information to help determine their appropriate use ratings, they were asked to implicitly consider cost as an additional factor in their evaluation of appropriate use.

In developing these criteria, the AUC Technical Panel was asked to assess whether the use of the test for each indication is appropriate, uncertain, or inappropriate, and was provided the following definition of appropriate use:

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

The technical panel scores each indication as follows:

Score 7–9

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

Score 4–6

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

Score 1–3

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

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

To prevent bias in the scoring process, the technical panel was deliberately not comprised solely of specialists in the particular procedure under evaluation. Specialists, while offering important clinical and technical insights, might have a natural tendency to rate the indications within their specialty as more appropriate than nonspecialists. In addition, care was taken in providing objective, nonbiased information, including guidelines and key references, to the technical panel.

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

3. General Assumptions

To prevent any inconsistencies in interpretation, specific assumptions are provided that were considered by the technical panel in rating the relevant clinical indications for the appropriate use of RNI:

1. Panel members were to assume that all radionuclide techniques with different radiopharmaceuticals and imaging protocols were available for each indication and that each was performed in a manner similar to that found in the published literature.
2. Radionuclide imaging is performed in accordance with best practice standards as delineated in the imaging guidelines for nuclear cardiology procedures (6). It is also

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

assumed that procedures are performed in an accredited facility with appropriately credentialed physicians.
3. Unless otherwise noted, all indications referred to SPECT MPI and positron emission tomography myocardial perfusion imaging. All radionuclide perfusion imaging indications also assume the use of electrocardiogram (ECG) gating, whenever possible, with determination of global ventricular function (i.e., left ventricular ejection fraction) and regional wall motion as part of the evaluation.
4. For all stress imaging, the mode of stress testing was assumed to be exercise for patients able to exercise. For patients unable to exercise, pharmacologic stress testing was assumed to be used. Further background on the rationale for the assumption of exercise testing is available in the ACC/AHA 2002 Guideline Update for Exercise Testing (7).
5. In the setting of a known acute coronary syndrome (ACS), the use of stress testing should be performed in conjunction with pharmacologic stress testing, not exercise.
6. The use of testing in the perioperative setting is assumed to have the potential to impact clinical decision making and to direct therapeutic interventions.
7. The category of "uncertain" should be used when insufficient clinical data is available for a definitive categorization or there is substantial disagreement regarding the appropriateness of that indication. The designation of "uncertain" is assumed to not provide grounds for denial of reimbursement.

4. Definitions

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

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

Determining Pretest Risk Assessment for Risk Stratification

Risk Assessment for Asymptomatic Patients

The indications on risk assessment include asymptomatic patients with suspected CAD. It is assumed that clinicians will use RNI studies in addition to standard methods of risk assessment as presented in the National Heart, Lung, and Blood Institute report on "Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III)" (ATP III) (8).

Coronary Heart Disease (CHD) Risk (Based on the ACC/AHA Scientific Statement on Cardiovascular Risk Assessment [9])

Absolute risk is defined as the probability of developing CHD, including myocardial infarction or CHD death over a given time period. The ATP III report specifies absolute risk for CHD over the next 10 years. CHD risk refers to 10-year risk for any hard cardiac event.

- **CHD Risk—Low**
  Defined by the age-specific risk level that is below average. In general, low risk will correlate with a 10-year absolute CHD risk less than 10%.
- **CHD Risk—Moderate**
  Defined by the age-specific risk level that is average or above average. In general, moderate risk will correlate with a 10-year absolute CHD risk between 10% and 20%.
- **CHD Risk—High†**
  Defined as the presence of diabetes mellitus in a patient 40 years of age or older, peripheral arterial disease or other coronary risk equivalents, or a 10-year absolute CHD risk of greater than 20%.

Pretest Probability of CAD for Symptomatic (Ischemic Equivalent) Patients: Once the physician determines the presence of symptoms that may represent obstructive CAD (ischemic equivalent present), the pretest probability of CAD should be assessed. There are a number of risk algorithms (10,11) available that can be used to calculate this probability. Clinicians should become familiar with those algorithms that pertain to the populations they encounter most often. In scoring the indications, the following probabilities, as calculated from any of the various available algorithms, should be applied.

- **Very low pretest probability:** Less than 5% pretest probability of CAD
- **Low pretest probability:** Less than 10% pretest probability of CAD
- **Intermediate pretest probability:** Between 10% and 90% pretest probability of CAD
- **High pretest probability:** Greater than 90% pretest probability of CAD

The method recommended by the ACC/AHA Guidelines for Chronic Stable Angina (12) is provided below as one example of a method used to calculate pretest probability and is a modification of a previously published

†Grundy et al. (9) cites Framingham when assigning patients with diabetes mellitus to a category of high short-term risk because these patients typically have multiple risk factors and have poor prognoses if they develop CHD.

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

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

High: Greater than 90% pretest probability. **Intermediate:** Between 10% and 90% pretest probability. **Low:** Between 5% and 10% pretest probability. **Very low:** Less than 5% pretest probability. *Modified from the ACC/AHA Exercise Testing Guidelines to reflect all age ranges (14).

literature review (13). Please refer to definitions of angina and to Table A. Please note that Table A only predicts pretest probability in patients without other complicating history or ECG findings. History and electrocardiographic evidence of prior infarction dramatically affect pretest probability. While not incorporated into the algorithm, CAD risk factors, discussed in the previous section, Determining Pretest Risk Assessment for Risk Stratification, may also affect pretest likelihood of CAD. Detailed nomograms are available that incorporate the effects of a history of prior infarction, electrocardiographic Q waves, electrocardiographic ST- and T-wave changes, diabetes, smoking, and hypercholesterolemia (14).

5. Abbreviations

ACS = acute coronary syndrome
CABG = coronary artery bypass grafting surgery
CAD = coronary artery disease
CHD = coronary heart disease
CT = computed tomography
ECG = electrocardiogram
ERNA = equilibrium radionuclide angiography
FP = First Pass
HF = heart failure
LBBB = left bundle-branch block
LV = left ventricular
MET = estimated metabolic equivalents of exercise
MI = myocardial infarction
MPI = myocardial perfusion imaging
PCI = percutaneous coronary intervention
PET = positron emission tomography
RNA = radionuclide angiography
RNI = radionuclide imaging
SPECT = single photon emission computed tomography
STEMI = ST-elevation myocardial infarction
UA/NSTEMI = unstable angina (UA) and non–ST-elevation myocardial infarction (NSTEMI)

6. Results of Ratings

The final ratings for cardiac RNI (Tables 1 to 8) are listed by indication sequentially as obtained from second-round rating sheets submitted by each panelist. The final score reflects the median score of the 15 panelists and has been labeled according to the 3 appropriate use categories of appropriate, uncertain, and inappropriate. Tables 9 to 11 present the indications by these categories.

There was generally less variation in ratings for the indications labeled as either appropriate or inappropriate, with 73% and 64%, respectively, showing agreement as defined in Section 2, Methods. There was, however, greater variability (less agreement) in the rating scores for indications defined as uncertain, with 11% showing agreement as defined above, suggesting greater variation in opinion. Two indications, 26 and 28, were distributed into each extreme such that the panel was classified as being in disagreement. However, these indications were already placed in the uncertain category so no changes were required to reflect disagreement. Across all categories, several indications failed to meet the definition of agreement. In such cases, the final distribution of scores across the panel contained a greater diversity of scores among panel members, but the scores were not so divergent (as defined by disagreement) as to necessitate a change in the final score.

7. Cardiac Radionuclide Imaging Appropriate Use Criteria (By Indication)

Table 1. Detection of CAD: Symptomatic

Indication		Appropriate Use Score (1–9)
Evaluation of Ischemic Equivalent (Non-Acute)		
1.	• Low pretest probability of CAD • ECG interpretable AND able to exercise	I (3)
2.	• Low pretest probability of CAD • ECG uninterpretable OR unable to exercise	A (7)
3.	• Intermediate pretest probability of CAD • ECG interpretable AND able to exercise	A (7)
4.	• Intermediate pretest probability of CAD • ECG uninterpretable OR unable to exercise	A (9)
5.	• High pretest probability of CAD • Regardless of ECG interpretability and ability to exercise	A (8)
Acute Chest Pain		
6.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • Low-risk TIMI score • Peak troponin: borderline, equivocal, minimally elevated	A (8)
7.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • High-risk TIMI score • Peak troponin: borderline, equivocal, minimally elevated	A (7)
8.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • Low-risk TIMI score • Negative peak troponin levels	A (8)
9.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • High-risk TIMI score • Negative peak troponin levels	A (8)
10.	• Definite ACS*	I (1)
Acute Chest Pain (Rest Imaging Only)		
11.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • Initial troponin negative • Recent or ongoing chest pain	A (7)

*See definition of ACS in Appendix A (based on ACC/AHA Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction) (24).

Table 2. Detection of CAD/Risk Assessment Without Ischemic Equivalent

	Indication	Appropriate Use Score (1–9)
	Asymptomatic	
12.	• Low CHD risk (ATP III risk criteria)	I (1)
13.	• Intermediate CHD risk (ATP III risk criteria) • ECG interpretable	I (3)
14.	• Intermediate CHD risk (ATP III risk criteria) • ECG uninterpretable	U (5)
15.	• High CHD risk (ATP III risk criteria)	A (7)
	New-Onset or Newly Diagnosed Heart Failure With LV Systolic Dysfunction Without Ischemic Equivalent	
16.	• No prior CAD evaluation AND no planned coronary angiography	A (8)
	New-Onset Atrial Fibrillation	
17.	• Part of evaluation when etiology unclear	U (6)
	Ventricular Tachycardia	
18.	• Low CHD risk (ATP III risk criteria)	A (7)
19.	• Intermediate or high CHD risk (ATP III risk criteria)	A (8)
	Syncope	
20.	• Low CHD risk (ATP III risk criteria)	I (3)
21.	• Intermediate or high CHD risk (ATP III risk criteria)	A (7)
	Elevated Troponin	
22.	• Troponin elevation without additional evidence of acute coronary syndrome	A (7)

Table 3. Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD

	Indication	Appropriate Use Score (1–9)
	Asymptomatic OR Stable Symptoms Normal Prior Stress Imaging Study	
23.	• Low CHD risk (ATP III risk criteria) • Last stress imaging study done less than 2 years ago	I (1)
24.	• Intermediate to high CHD risk (ATP III risk criteria) • Last stress imaging study done less than 2 years ago	I (3)
25.	• Low CHD risk (ATP III risk criteria) • Last stress imaging study done more than or equal to 2 years ago	I (3)
26.	• Intermediate to high CHD risk (ATP III risk criteria) • Last stress imaging study done more than or equal to 2 years ago	U (6)
	Asymptomatic OR Stable Symptoms Abnormal Coronary Angiography OR Abnormal Prior Stress Imaging Study, No Prior Revascularization	
27.	• Known CAD on coronary angiography OR prior abnormal stress imaging study • Last stress imaging study done less than 2 years ago	I (3)
28.	• Known CAD on coronary angiography OR prior abnormal stress imaging study • Last stress imaging study done more than or equal to 2 years ago	U (5)
	Prior Noninvasive Evaluation	
29.	• Equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern	A (8)
	New or Worsening Symptoms	
30.	• Abnormal coronary angiography OR abnormal prior stress imaging study	A (9)
31.	• Normal coronary angiography OR normal prior stress imaging study	U (6)
	Coronary Angiography (Invasive or Noninvasive)	
32.	• Coronary stenosis or anatomic abnormality of uncertain significance	A (9)
	Asymptomatic Prior Coronary Calcium Agatston Score	
33.	• Agatston score less than 100	I (2)
34.	• Low to intermediate CHD risk • Agatston score between 100 and 400	U (5)
35.	• High CHD risk • Agatston score between 100 and 400	A (7)
36.	• Agatston score greater than 400	A (7)
	Duke Treadmill Score	
37.	• Low-risk Duke treadmill score	I (2)
38.	• Intermediate-risk Duke treadmill score	A (7)
39.	• High-risk Duke treadmill score	A (8)

Table 4. Risk Assessment: Preoperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions*

Indication		Appropriate Use Score (1–9)
Low-Risk Surgery		
40.	• Preoperative evaluation for noncardiac surgery risk assessment	I (1)
Intermediate-Risk Surgery		
41.	• Moderate to good functional capacity (greater than or equal to 4 METs)	I (3)
42.	• No clinical risk factors†	I (2)
43.	• Greater than or equal to 1 clinical risk factor • Poor or unknown functional capacity (less than 4 METs)	A (7)
44.	• Asymptomatic up to 1 year postnormal catheterization, noninvasive test, or previous revascularization	I (2)
Vascular Surgery		
45.	• Moderate to good functional capacity (greater than or equal to 4 METs)	I (3)
46.	• No clinical risk factors†	I (2)
47.	• Greater than or equal to 1 clinical risk factor • Poor or unknown functional capacity (less than 4 METS)	A (8)
48.	• Asymptomatic up to 1 year postnormal catheterization, noninvasive test, or previous revascularization	I (2)

*Refer to Table A1. †Refer to Table A2.

Table 5. Risk Assessment: Within 3 Months of an Acute Coronary Syndrome

Indication		Appropriate Use Score (1–9)
STEMI		
49.	• Primary PCI with complete revascularization • No recurrent symptoms	I (2)
50.	• Hemodynamically stable, no recurrent chest pain symptoms or no signs of HF • To evaluate for inducible ischemia • No prior coronary angiography	A (8)
51.	• Hemodynamically unstable, signs of cardiogenic shock, or mechanical complications	I (1)
UA/NSTEMI		
52.	• Hemodynamically stable, no recurrent chest pain symptoms or no signs of HF • To evaluate for inducible ischemia • No prior coronary angiography	A (9)
ACS–Asymptomatic Postrevascularization (PCI or CABG)		
53.	• Evaluation prior to hospital discharge	I (1)
Cardiac Rehabilitation		
54.	• Prior to initiation of cardiac rehabilitation (as a stand-alone indication)	I (3)

Table 6. Risk Assessment: Postrevascularization (Percutaneous Coronary Intervention or Coronary Artery Bypass Graft)*

Indication		Appropriate Use Score (1–9)
Symptomatic		
55.	• Evaluation of ischemic equivalent	A (8)
Asymptomatic		
56.	• Incomplete revascularization • Additional revascularization feasible	A (7)
57.	• Less than 5 years after CABG	U (5)
58.	• Greater than or equal to 5 years after CABG	A (7)
59.	• Less than 2 years after PCI	I (3)
60.	• Greater than or equal to 2 years after PCI	U (6)
Cardiac Rehabilitation		
61.	• Prior to initiation of cardiac rehabilitation (as a stand-alone indication)	I (3)

*In patients who have had multiple coronary revascularization procedures, consider the most recent procedure.

Table 7. Assessment of Viability/Ischemia

Indication		Appropriate Use Score (1–9)
Ischemic Cardiomyopathy/Assessment of Viability		
62.	• Known severe LV dysfunction • Patient eligible for revascularization	A (9)

Table 8. Evaluation of Ventricular Function

Indication		Appropriate Use Score (1–9)
Evaluation of LV Function		
63.	• Assessment of LV function with radionuclide angiography (ERNA or FP RNA) • In absence of recent reliable diagnostic information regarding ventricular function obtained with another imaging modality	A (8)
64.	• Routine* use of rest/stress ECG-gating with SPECT or PET MPI	A (9)
65.	• Routine* use of stress FP RNA in conjunction with rest/stress gated SPECT MPI	I (3)
66.	• Selective use of stress FP RNA in conjunction with rest/stress gated SPECT MPI • Borderline, mild, or moderate stenoses in 3 vessels OR moderate or equivocal left main stenosis in left dominant system	U (6)
Use of Potentially Cardiotoxic Therapy (e.g., Doxorubicin)		
67.	• Serial assessment of LV function with radionuclide angiography (ERNA or FP RNA) • Baseline and serial measures after key therapeutic milestones or evidence of toxicity	A (9)

*Performed under most clinical circumstances, except in cases with technical inability or clear-cut redundancy of information.

8. Cardiac Radionuclide Imaging Appropriate Use Criteria (By Appropriate Use Criteria)

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

Indication		Appropriate Use Score (1–9)
Detection of CAD: Symptomatic Evaluation of Ischemic Equivalent (Nonacute)		
2.	• Low pretest probability of CAD • ECG uninterpretable OR unable to exercise	A (7)
3.	• Intermediate pretest probability of CAD • ECG interpretable AND able to exercise	A (7)
4.	• Intermediate pretest probability of CAD • ECG uninterpretable OR unable to exercise	A (9)
5.	• High pretest probability of CAD • Regardless of ECG interpretability and ability to exercise	A (8)
Detection of CAD: Symptomatic Acute Chest Pain		
6.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • Low-risk TIMI score • Peak troponin: borderline, equivocal, minimally elevated	A (8)
7.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • High-risk TIMI score • Peak troponin: borderline, equivocal, minimally elevated	A (7)
8.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • Low-risk TIMI score • Negative peak troponin levels	A (8)
9.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • High-risk TIMI score • Negative peak troponin levels	A (8)
Detection of CAD: Symptomatic Acute Chest Pain (Rest Imaging Only)		
11.	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically ventricular paced rhythm • Initial troponin negative • Recent or ongoing chest pain	A (7)
Detection of CAD/Risk Assessment: Without Ischemic Equivalent Asymptomatic		
15.	• High CHD risk (ATP III risk criteria)	A (7)
Detection of CAD/Risk Assessment: Without Ischemic Equivalent New-Onset or Newly Diagnosed Heart Failure With LV Systolic Dysfunction Without Ischemic Equivalent		
16.	• No prior CAD evaluation AND no planned coronary angiography	A (8)
Detection of CAD/Risk Assessment: Without Ischemic Equivalent Ventricular Tachycardia		
18.	• Low CHD risk (ATP III risk criteria)	A (7)
19.	• Intermediate or high CHD risk (ATP III risk criteria)	A (8)
Detection of CAD/Risk Assessment: Without Ischemic Equivalent Syncope		
21.	• Intermediate or high CHD risk (ATP III risk criteria)	A (7)
Detection of CAD/Risk Assessment: Without Ischemic Equivalent Elevated Troponin		
22.	• Troponin elevation without additional evidence of acute coronary syndrome	A (7)
Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Prior Noninvasive Evaluation		
29.	• Equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern	A (8)
Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD New or Worsening Symptoms		
30.	• Abnormal coronary angiography OR abnormal prior stress imaging study	A (9)

Table 9. Continued

	Indication	Appropriate Use Score (1–9)
	Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Coronary Angiography (Invasive or Noninvasive)	
32.	• Coronary stenosis or anatomic abnormality of uncertain significance	A (9)
	Risk Assessment with Prior Test Results and/or Known Chronic Stable CAD Asymptomatic Prior Coronary Calcium Agatston Score	
35.	• High CHD risk • Agatston score between 100 and 400	A (7)
36.	• Agatston score greater than 400	A (7)
	Risk Assessment with Prior Test Results and/or Known Chronic Stable CAD Duke Treadmill Score	
38.	• Intermediate-risk Duke treadmill score	A (7)
39.	• High-risk Duke treadmill score	A (8)
	Risk Assessment: Preoperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions* Intermediate-Risk Surgery	
43.	• Greater than or equal to 1 clinical risk factor • Poor or unknown functional capacity (less than 4 METS)	A (7)
	Risk Assessment: Preoperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions* Vascular Surgery	
47.	• Greater than or equal to 1 clinical risk factor • Poor or unknown functional capacity (less than 4 METS)	A (8)
	Risk Assessment: Within 3 Months of an ACS STEMI	
50.	• Hemodynamically stable, no recurrent chest pain symptoms or no signs of HF • To evaluate for inducible ischemia • No prior coronary angiography	A (8)
	Risk Assessment: Within 3 Months of an ACS UA/NSTEMI	
52.	• Hemodynamically stable, no recurrent chest pain symptoms or no signs of HF • To evaluate for inducible ischemia • No prior coronary angiography	A (9)
	Risk Assessment: Postrevascularization (PCI or CABG)† Symptomatic	
55.	• Evaluation of ischemic equivalent	A (8)
	Risk Assessment: Postrevascularization (PCI or CABG)† Asymptomatic	
56.	• Incomplete revascularization • Additional revascularization feasible	A (7)
58.	• Greater than or equal to 5 years after CABG	A (7)
	Assessment of Viability/Ischemia Ischemic Cardiomyopathy/Assessment of Viability	
62.	• Known severe LV dysfunction • Patient eligible for revascularization	A (9)
	Evaluation of Ventricular Function Evaluation of LV Function	
63.	• Assessment of LV function with radionuclide angiography (ERNA or FP RNA) • In absence of recent reliable diagnostic information regarding ventricular function obtained with another imaging modality	A (8)
64.	• Routine‡ use of rest/stress ECG-gating with SPECT or PET MPI	A (9)
	Evaluation of Ventricular Function Use of Potentially Cardiotoxic Therapy (e.g., Doxorubicin)	
67.	• Serial assessment of LV function with radionuclide angiogram (ERNA or FP RNA) • Baseline and serial measures after key therapeutic milestones or evidence of toxicity	A (9)

*See Table A1. †In patients who have had multiple coronary revascularization procedures, consider the most recent procedure. ‡Performed under most clinical circumstances, except in cases with technical inability, or clear-cut redundancy of information.

Table 10. Uncertain Indications (Median Score 4–6)

Indication		Appropriate Use Score (1–9)
Detection of CAD/Risk Assessment Without Ischemic Equivalent Asymptomatic		
14.	• Intermediate CHD risk (ATP III risk criteria) • ECG uninterpretable	U (5)
Detection of CAD/Risk Assessment Without Ischemic Equivalent New-Onset Atrial Fibrillation		
17.	• Part of evaluation when etiology unclear	U (6)
Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Asymptomatic OR Stable Symptoms Normal Prior Stress Imaging Study		
26.	• Intermediate to high CHD risk (ATP III risk criteria) • Last stress imaging study done more than or equal to 2 years ago	U (6)
Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Asymptomatic OR Stable Symptoms Abnormal Coronary Angiography OR Abnormal Prior Stress Imaging Study, No Prior Revascularization		
28.	• Poor exercise tolerance (less than or equal to 4 METs) • Intermediate clinical risk predictors	U (5)
Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD New or Worsening Symptoms		
31.	• Normal coronary angiography OR normal prior stress imaging study	U (6)
Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Asymptomatic Prior Coronary Calcium Agatston Score		
34.	• Low to intermediate CHD risk • Agatston score between 100 and 400	U (5)
Risk Assessment: Postrevascularization (PCI or CABG)* Asymptomatic		
57.	• Less than 5 years after CABG	U (5)
60.	• Greater than or equal to 2 years after PCI	U (6)
Evaluation of Ventricular Function Evaluation of Left Ventricular Function		
66.	• Selective use of stress FP RNA in conjunction with rest/stress gated SPECT MPI • Borderline, mild, or moderate stenoses in 3 vessels OR moderate or equivocal left main stenosis in left dominant system	U (6)

*In patients who have had multiple coronary revascularization procedures, consider the most recent procedure.

Table 11. Inappropriate Indications (Median Score 1–3)

	Indication	Appropriate Use Score (1–9)
	Detection of CAD: Symptomatic Evaluation of Ischemic Equivalent (Nonacute)	
1.	• Low pretest probability of CAD • ECG interpretable AND able to exercise	I (3)
	Detection of CAD: Symptomatic Acute Chest Pain	
10.	• Definite ACS*	I (1)
	Detection of CAD/Risk Assessment Without Ischemic Equivalent Asymptomatic	
12.	• Low CHD risk (ATP III risk criteria)	I (1)
13.	• Intermediate CHD risk (ATP III risk criteria) • ECG interpretable	I (3)
	Detection of CAD/Risk Assessment Without Ischemic Equivalent Syncope	
20.	• Low CHD risk (ATP III risk criteria)	I (3)
	Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Asymptomatic OR Stable Symptoms Normal Prior Stress Imaging Study	
23.	• Low CHD risk (ATP III risk criteria) • Last stress imaging study done less than 2 years ago	I (1)
24.	• Intermediate to high CHD risk (ATP III risk criteria) • Last stress imaging study done less than 2 years ago	I (3)
25.	• Low CHD risk (ATP III risk criteria) • Last stress imaging study done more than or equal to 2 years ago	I (3)
	Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Asymptomatic OR Stable Symptoms Abnormal Coronary Angiography OR Abnormal Prior Stress Imaging Study, No Prior Revascularization	
27.	• Known CAD on coronary angiography OR prior abnormal stress imaging study • Last stress imaging study done less than 2 years ago	I (3)
	Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Asymptomatic Prior Coronary Calcium Agatston Score	
33.	• Agatston score less than 100	I (2)
	Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD Duke Treadmill Score	
37.	• Low-risk Duke treadmill score	I (2)
	Risk Assessment: Preoperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions* Low-Risk Surgery	
40.	• Preoperative evaluation for noncardiac surgery risk assessment	I (1)
	Risk Assessment: Preoperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions* Intermediate-Risk Surgery	
41.	• Moderate to good functional capacity (greater than or equal to 4 METs)	I (3)
42.	• No clinical risk factors†	I (2)
44.	• Asymptomatic up to 1 year postnormal catheterization, noninvasive test, or previous revascularization	I (2)
	Risk Assessment: Preoperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions* Vascular Surgery	
45.	• Moderate to good functional capacity (greater than or equal to 4 METs)	I (3)
46.	• No clinical risk factors†	I (2)
48.	• Asymptomatic up to 1 year postnormal catheterization, noninvasive test, or previous revascularization	I (2)
	Risk Assessment: Within 3 Months of an ACS STEMI	
49.	• Primary PCI with complete revascularization • No recurrent symptoms	I (2)
51.	• Hemodynamically unstable, signs of cardiogenic shock, or mechanical complications	I (1)
	Risk Assessment: Within 3 Months of an ACS ACS–Asymptomatic Postrevascularization (PCI or CABG)	
53.	• Evaluation prior to hospital discharge	I (1)

Table 11. Continued

Indication		Appropriate Use Score (1–9)
Risk Assessment: Within 3 Months of an ACS Cardiac Rehabilitation		
54.	• Prior to initiation of cardiac rehabilitation (as a stand-alone indication)	I (3)
Risk Assessment: Postrevascularization (PCI or CABG)* Asymptomatic		
59.	• Less than 2 years after PCI	I (3)
Risk Assessment: Postrevascularization (PCI or CABG)‡ Cardiac Rehabilitation		
61.	• Prior to initiation of cardiac rehabilitation (as a stand-alone indication)	I (3)
Evaluation of Ventricular Function Evaluation of LV Function		
65.	• Routine§ use of stress FP RNA in conjunction with rest/stress gated SPECT MPI	I (3)

*Refer to Table A1. †Refer to Table A2. ‡In patients who have had multiple coronary revascularization procedures, consider the most recent procedure. §Performed under most clinical circumstances, except in cases with technical inability, or clear-cut redundancy of information.

9. Discussion

This document is a revision of the original SPECT MPI Appropriateness Criteria (1) published 4 years earlier, written to reflect changes in test utilization, to add insight provided by interim clinical data, and to clarify cardiac RNI use where omissions or lack of clarity existed in the original criteria. This is consistent with the commitment to revise and refine AUC on a frequent basis. Published trials and a societal review have highlighted a significant number of clinical scenarios that were either uncertain or could not be categorized with the original criteria and warranted reconsideration (15–17). Additionally, trials and reviews have suggested new clinical indications to consider for this update of AUC for RNI.

In addition to adding new clinical indications and clarifying existing indications from the original SPECT MPI Appropriateness Criteria (1) document, the writing group, technical panel, and/or external reviewers of the RNI document also revised specific definitions and assumptions. Four additional assumptions were added. The first addressed accordance with best practice standards as delineated in the imaging guidelines for nuclear cardiology procedures (6) as well as ensuring that procedures are performed in an accredited facility. The second new assumption addressed the use of pharmacologic stress testing versus exercise stress testing in the setting of an ACS. The third new assumption emphasized that in the perioperative setting, the use of RNI would have the potential to impact clinical decision making and to direct therapeutic interventions. This assumption was added to enhance consistency with the updated 2007 ACC/AHA Guideline for Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery (18). The fourth new assumption addressed the category of uncertain indications and clarified the relationship between such a rating and grounds for reimbursement.

The writing group also revised the definition of "chest pain syndrome" that had caused confusion when applying the original SPECT MPI document. The original definition of chest pain syndrome focused only on symptoms and excluded other clinical findings, such as new ECG changes that suggest the presence of obstructive CAD and may warrant RNI testing. Therefore, a new term "ischemic equivalent" was developed to encompass chest pain syndromes as well as other symptoms and signs that the clinician believes may be due to obstructive CAD. This revision was supported by the writing group, technical panel, and external reviewers.

The AUC in this report provide an estimate of whether it is reasonable to use cardiac RNI for a particular clinical scenario, such as those 67 indications listed in this document. These criteria are expected to be useful for clinicians, health care facilities, and third-party payers engaged in the delivery of cardiovascular imaging. Experience with already published AUC (1–3) has shown their value across a broad range of situations, guiding care of individual patients, educating caregivers, and informing policy decisions regarding reimbursement for cardiovascular imaging.

Appropriate use criteria represent the first component of the chain of quality recommendations for cardiovascular imaging (19). After ensuring proper test selection, the achievement of quality in imaging includes adherence to best practices in image acquisition, image interpretation and results communication, as well as incorporation of findings into clinical care. All components are important for optimal patient care, although not addressed in this report. The development of AUC and their ranking by the technical panel assumes that other quality standards have been met.

Although these criteria are intended to provide guidance for patients and clinicians, they are not intended to serve as substitutes for sound clinical judgment and practice experience. The writing group recognizes that many patients encountered in clinical practice may not be represented in these AUC or may have extenuating features when compared with the clinical scenarios presented. Although the appropriate use ratings reflect critical medical literature as

well as expert consensus, physicians and other stakeholders should understand the role of clinical judgment in determining whether to order a test for an individual patient. Additionally, uncertain indications often require individual physician judgment and understanding of the patient to better determine the usefulness of a test for a particular scenario. As such, the ranking of an indication as uncertain (4 to 6) should not be viewed as limiting the use of cardiac RNI for such patients. It should be emphasized that the technical panel was instructed that the "uncertain" designation was still designed to be considered as a "reimbursable" category.

These ratings are intended to evaluate the appropriate use of specific patient scenarios to determine overall patterns of care regarding cardiac RNI. In situations where there is substantial variation between the appropriate use rating and what the clinician believes is the best recommendation for the patient, further considerations or actions, such as a second opinion, may be appropriate. Moreover, it is not anticipated that all physicians or facilities will have 100% of their cardiac radionuclide procedures deemed appropriate. However, related to the overall patterns of care, if the national average of appropriate and uncertain ratings is 80%, for example, and a physician or facility has a 40% rate of inappropriate procedures, further examination of the patterns of care may be warranted and helpful.

Panelists were asked specifically to rate each indication according to the definition of appropriate use (see Section 2, Methods) and to not necessarily consider comparisons to other imaging procedures or other AUC documents while completing their ratings, However, panelists were also provided with links to relevant guideline recommendations as well as previously published AUC documents to ensure they were adequately educated on all relevant medical literature when rating the indications. Whereas the newer modalities of CCTA and CMR perfusion are not as well studied, RNI and stress echocardiography have robust bodies of evidence to support their use. The overwhelming majority of final ratings of cardiac RNI and stress echocardiography were concordant for similar clinical indications. However, a few of the final scores and rating categories reported in this document differ from those previously published for stress echocardiography (2). Readers should note, however, that the categorical summaries tend to accentuate differences that sometimes are slight. For example, small fluctuations in a median rating (e.g., 4 versus 3) will cause an indication to switch appropriate use categories (from uncertain to inappropriate). There are several potential reasons for these discordant occurrences. The most likely reason for this is a simple variation in the ratings by the different panel members, whether due to different backgrounds levels and types of clinical experience or interpretations of data. The RAND process has documented that the interpretation of the literature by different sets of experts can yield slightly different final ratings (5). Inconsistency in wording of indications for the cardiac RNI and stress echocardiography panels has also likely contributed to differences in the ratings of some scenarios. Finally, true differences in the data reported in the literature regarding the modalities might explain some of the discordance.

9.1. Cardiac Radionuclide Imaging Appropriate Use Criteria

The clinical scenarios included in this report were designed to reflect the most common and important potential applications for cardiac RNI. After the preparation of a draft manuscript by the writing group and extensive review from external editors and then by the technical panel itself, the result is a set of scenarios that clearly define patient-specific applications.

The primary objective of this report is to provide guidance regarding the suitability of cardiac RNI for diverse clinical scenarios. As with previous AUC documents, consensus among the raters was desirable, but an attempt to achieve complete agreement within this diverse panel would have been artificial and was not the goal of the process. Two rounds of ratings with substantial discussion among the technical panelists concerning the ratings did lead to some consensus among panelists. However, further attempts to drive consensus would have diluted true differences in opinion among panelists and therefore was not undertaken.

Among the 67 indications, 33 were classified as appropriate, while uncertain and inappropriate designations were assigned for 9 and 25 indications, respectively.

To facilitate implementation of these AUC, an algorithm is presented in Figure 1, which presents a hierarchy of potential test ordering based on clinical presentation. The purpose of this algorithm is to help avoid situations in which the AUC failed to follow the true clinical reasons for test ordering, such as using an indication designed for assessment of chest pain even when a patient may have already undergone revascularization or a prior imaging procedure.

Table 1 focused on the diagnostic value of RNI. As shown in Figure 2, patients with an ischemic equivalent, consisting of symptoms associated with CAD or ECG findings, were divided based on the likelihood of ischemic heart disease. RNI was appropriate in patients with an intermediate or high likelihood of CAD, as it was in patients with a low likelihood if they were unable to exercise or had an uninterpretable ECG. The technical panel specifically decided to incorporate Thrombolysis In Myocardial Infarction (TIMI) scores into the indications describing acute chest pain syndromes to provide a more comprehensive risk assessment model and one that was consistent with contemporary literature. The technical panel somewhat arbitrarily selected a TIMI score of 2 as a threshold value for low and high risk, as the actual value is currently not defined in guidelines (20). Regarding troponin values, "peak" troponin was used for the indication, implying more than 1 sample was obtained, and serial testing was performed prior to a stress procedure. The technical panel felt it was best not to provide a cutoff value for troponin elevation, but instead

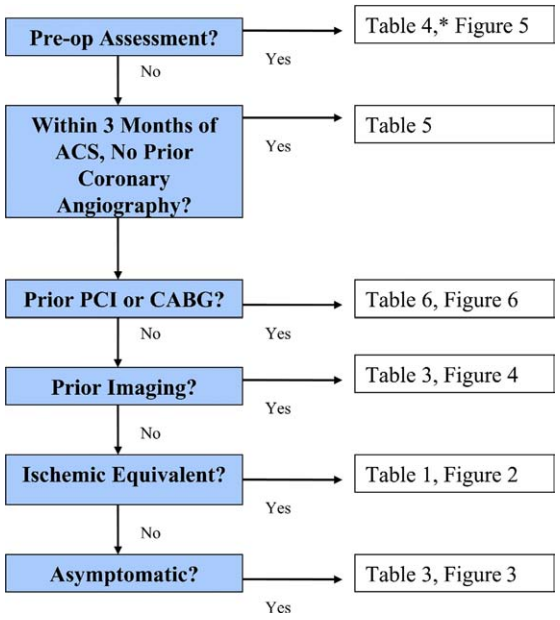

Figure 1. Hierarchy of Potential Test Ordering Based on Clinical Presentation

For those patients who may be classified into more than 1 of the clinical indication tables and/or algorithms, this flow chart places clinical conditions into a hierarchy to aid in assessing appropriateness for radionuclide imaging. *Symptomatic patients who are being considered for a preoperative evaluation for noncardiac surgery should begin down the algorithm as if "No."

recommended referring to the assay's definition of the "borderline/equivocal/slightly elevated" category, as this would preserve the "possible ACS" definition. For patients with a suspected ACS, RNI was considered appropriate irrespective of the TIMI score or whether or not their troponin levels were elevated. These potential discriminators were included by the writing group, but were not felt to assist RNI utilization by the technical panel.

Table 2 primarily focused on the asymptomatic patient and is reflected in Figure 3. RNI was felt to be appropriate only in high CHD risk patients, and in those with intermediate CHD risk with an uninterpretable ECG, RNI was considered "uncertain." The presence of unexplained troponin elevation, newly diagnosed heart failure, and ventricular tachycardia were appropriate indications for RNI, but RNI was of uncertain appropriateness in the setting of atrial fibrillation. This latter category was not divided by CHD risk per the technical panel's request and was based on recent data (21). The appropriate use of RNI in the setting of syncope was dependent on CHD risk.

The use of RNI in patients with prior test results was presented in Table 3. As shown in Figure 4, RNI was inappropriate if prior test results were known, except when performed more than 2 years later and only if an abnormal study was previously present or if the patient was at intermediate or greater CHD risk. In those circumstances, RNI use was "uncertain." When new or worsening symptoms were present, RNI was appropriate with prior abnormal results, but was uncertain if the prior study was normal. Regarding patients with prior coronary artery calcium (CAC) scoring, RNI was inappropriate in those with a CAC score less than 100. However, RNI was appropriate in those with a CAC score greater than 400 or between 100 and 400 with intermediate CHD risk and was uncertain in those with a CAC score between 100 and 400 and low-intermediate CHD risk. Finally, a low-risk Duke treadmill score derived from a prior exercise study was felt to be an inappropriate indication for RNI.

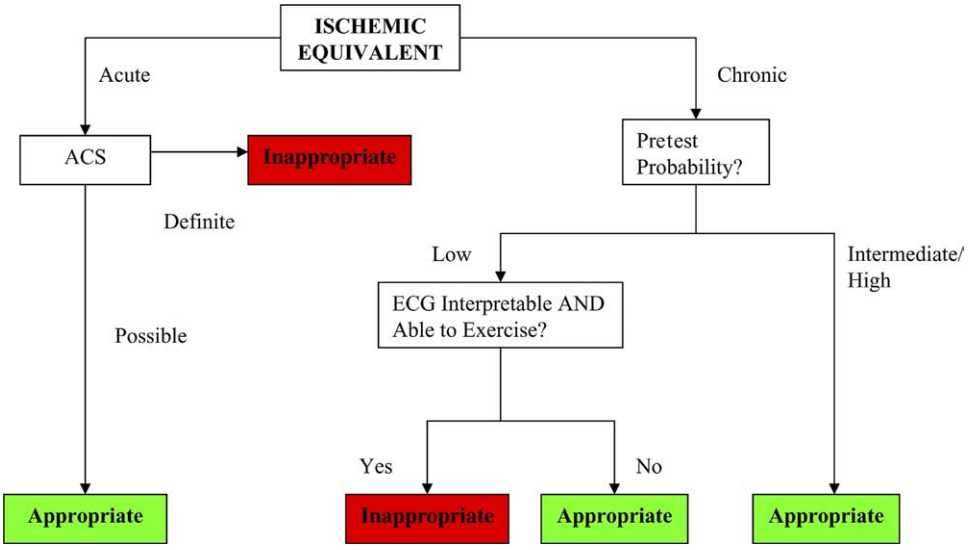

Figure 2. Potential Applications for Chest Pain

Patients with an ischemic equivalent, consisting of symptoms associated with CAD or ECG findings, were divided based on the likelihood of CAD. If patients had an intermediate or high likelihood for CAD, RNI was appropriate. RNI was also appropriate for patients at low likelihood if they were unable to exercise or had an uninterpretable ECG. For patients with a suspected ACS, RNI was appropriate irrespective of the TIMI score or whether or not their troponin levels were elevated.

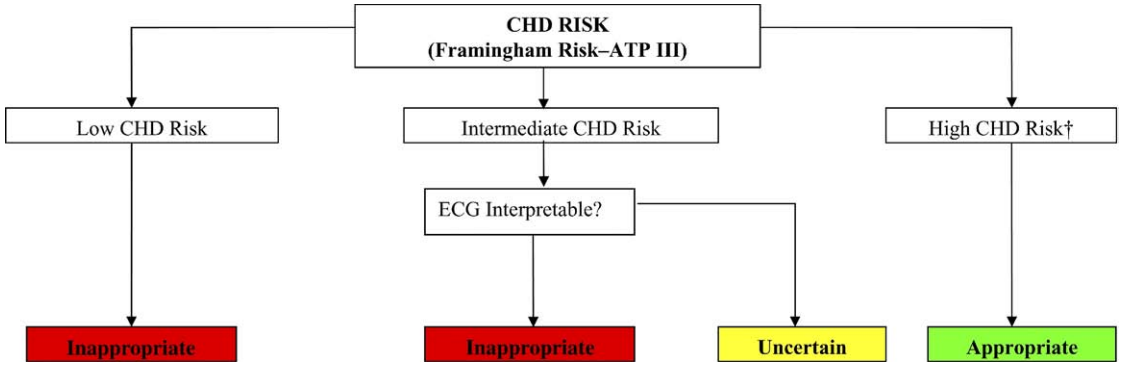

Figure 3. Potential Applications for Asymptomatic* Patients

Only in high CHD risk patients was RNI felt to be appropriate, although those with intermediate CHD risk with an uninterpretable ECG were uncertain. The presence of syncope did not alter the appropriateness of patients separate from their CHD risk, with low-risk patients being inappropriate and high-risk patients being appropriate. *Asymptomatic patients exhibiting the following clinical indications are appropriate (or uncertain) for RNI and do not require risk assessment by either step: 1) new-onset or newly diagnosed heart failure with LV systolic dysfunction without ischemic equivalent who have not had a prior CAD evaluation AND have no planned coronary angiography (Appropriate); 2) ventricular tachycardia (Appropriate); 3) elevated troponin without additional evidence of acute coronary syndrome (Appropriate); 4) new-onset atrial fibrillation (Uncertain). †Includes diabetes mellitus or the presence of other clinical atherosclerotic disease, including peripheral arterial disease, abdominal aortic aneurysm, carotid artery disease, and other likely forms of clinical disease (e.g., renal artery disease).

The new guidelines for perioperative risk stratification (25) mandated a major revision of the original SPECT MPI criteria (1). Table 4 lists the clinical scenarios and the appropriate use ratings, with Figure 5 summarizing these scores. Overall, RNI was felt to be inappropriate for preoperative risk assessment except in the setting of intermediate risk or vascular surgery when at least 1 risk factor is present and the patient has a limited functional capacity.

Following an acute ACS, it was felt that RNI was inappropriate within 3 months after ACS except in those patients where a prior coronary angiogram had not been performed. Following revascularization with PCI or CABG in a more

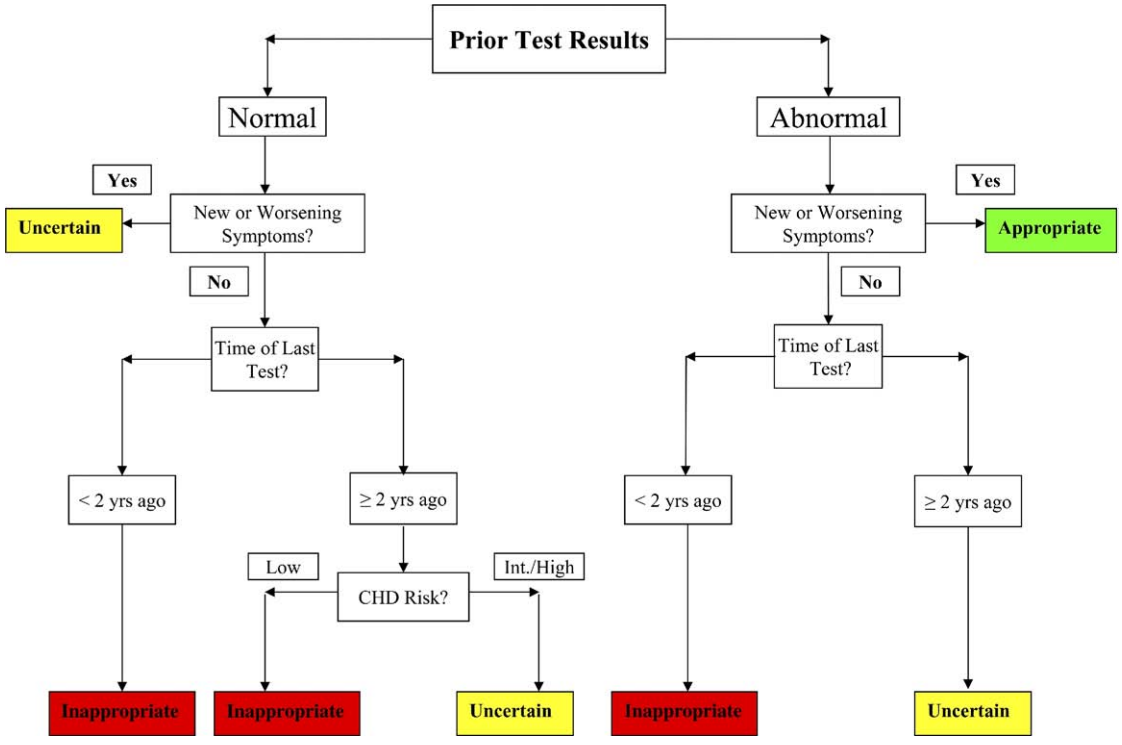

Figure 4. Prior Test Results*

When new or worsening symptoms were present, RNI was appropriate if prior abnormal results were present, but was uncertain if the prior study was normal. RNI was inappropriate when no or stable symptoms were present if prior test results were known, except when performed more than 2 years later, and only if an abnormal study was previously present or if the patient was at intermediate or greater CHD risk. In those circumstances, RNI use was "uncertain." *RNI is appropriate if prior test results were uncertain in the following 2 scenarios: 1) Coronary Angiography: coronary stenosis or anatomic abnormality of uncertain significance; OR 2) Prior Noninvasive Evaluation: equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern.

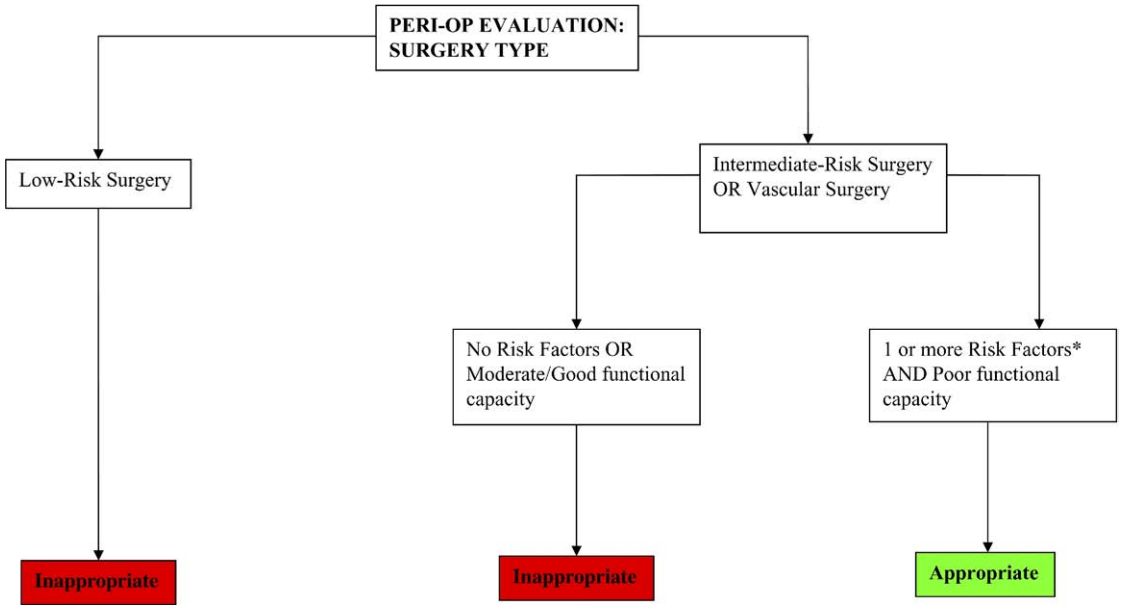

Figure 5. Perioperative Evaluation

RNI was felt to be inappropriate for preoperative risk assessment except in the setting of intermediate risk or vascular surgery when at least 1 risk factor is present and the patient has poor or unknown functional capacity. Additionally, patients who are asymptomatic up to 1 year postnormal catheterization, noninvasive test, or previous revascularization in the setting of intermediate risk or vascular surgery were also rated as inappropriate for RNI. *History of ischemic heart disease, compensated or prior heart failure, cerebrovascular disease, diabetes mellitus (requiring insulin), or renal insufficiency (creatinine >2.0).

chronic setting, recurrence of symptoms or the presence of suspected incomplete revascularization were felt to be appropriate indications. The revascularization procedure and the time elapsed before considering RNI resulted in a variety of appropriate use ratings, as depicted in Table 6 and Figure 6. Both the writing group and the technical panel spent a great deal of time deliberating the issue of whether to incorporate a distinction between the presence or absence of symptoms prior to revascularization into the indications, as patients may have undergone testing in the setting of silent ischemia. The writing group initially elected to keep prerevascularization symptomatology as a discrimination point within the indication, in keeping with the prior SPECT MPI criteria and those for stress echocardiography. However, the technical panel ultimately decided to remove the distinction due to the lack sufficient evidence that this qualification was relevant.

Table 8 focuses on ventricular function assessment, not MPI, in an effort to delineate appropriateness of gated SPECT, first pass radionuclide angiography (FP RNA), and equilibrium radionuclide angiography. The routine use of FP RNA imaging was deemed inappropriate but was uncertain when used in a selective fashion, such as for those patients with suspected multivessel coronary disease.

Several changes were present when comparing the original SPECT MPI criteria to the new RNI AUC. Specifically, indications 26 and 28 are now "uncertain" compared with the previous designation of "appropriate"—these changes likely reflect increased knowledge and/or differing technical panel composition. Additionally, indication 32 has changed from uncertain to appropriate.

9.2. Application of Criteria

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

It is expected that services performed for appropriate indications will be considered reimbursable. In contrast, services performed for inappropriate indications should likely require additional documentation to justify reimbursement because of the unique circumstances or the clinical profile that must exist in such a patient. It is critical to emphasize that the writing group, technical panel, AUC Working Group, and clinical community do not believe an uncertain rating is grounds to deny reimbursement for cardiac RNI. Rather, uncertain ratings are those where the available data vary and many other factors exist that may affect the decision to perform or not perform cardiac RNI. The opinions of the technical panel often varied for these indications, reflecting that additional research is needed. Indications with high clinical volume that are rated as uncertain identify important areas for further research.

In conclusion, this document represents the current understanding of the clinical benefit of cardiac RNI with respect to health outcomes and survival. It is intended to

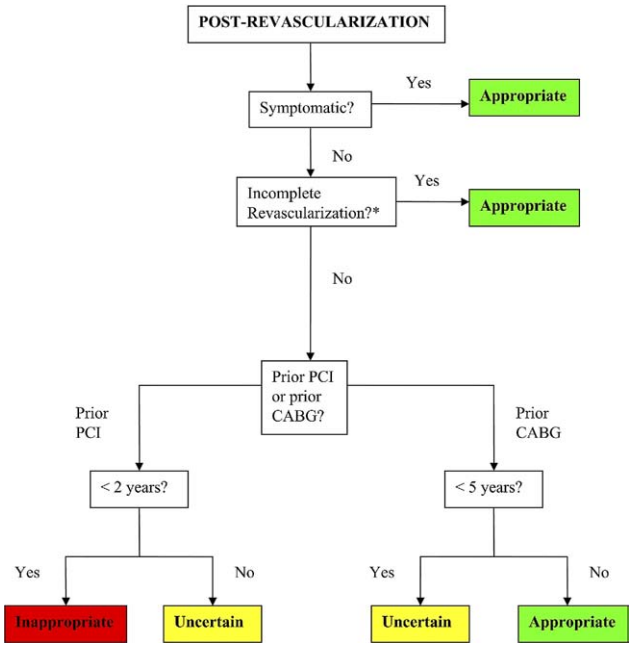

Figure 6. Postrevascularization

Following revascularization with PCI or CABG in a more chronic (>3 months) setting, recurrence of symptoms or the presence of suspected incomplete revascularization were felt to be appropriate indications for RNI. For asymptomatic patients less than 2 years after a PCI, RNI was rated inappropriate. For asymptomatic patients at less than 5 years after CABG or those at greater than or equal to 2 years after PCI, RNI was rated uncertain. If CABG was performed more than 5 years ago, RNI is appropriate. *Assumes that additional revascularization is feasible.

provide a practical guide to clinicians and patients when considering cardiac RNI. As with other AUC documents, some of these ratings will require research and further evaluation to provide the greatest information and benefit to clinical decision making. Finally, it will be necessary to periodically assess and update the indications and criteria as technology evolves and new data and field experience becomes available.

Appendix A: Additional Cardiac Radionuclide Imaging Definitions

Angina: as defined by the ACC/AHA Guidelines on Exercise Testing (7)

- ***Typical* Angina (Definite):**
  1. Substernal chest pain or discomfort that is
  2. provoked by exertion or emotional stress and
  3. relieved by rest and/or nitroglycerin (22).
- ***Atypical* Angina (Probable):** Chest pain or discomfort that **lacks one** of the characteristics of definite or typical angina (22).
- ***Nonanginal* Chest Pain:** Chest pain or discomfort that **meets one or none** of the typical angina characteristics.

ACS: As defined by the ACC/AHA Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction: patients with an ACS include those whose clinical presentations cover the following range of diagnoses: unstable angina, myocardial infarction without ST elevation (NSTEMI), and myocardial infarction with ST elevation (STEMI) (23).

Evaluating Perioperative Risk for Noncardiac Surgery

METHOD FOR DETERMINING PERIOPERATIVE RISK

See Figure A1, "Stepwise Approach to Perioperative Cardiac Assessment," from the ACC/AHA 2007 Perioperative Guidelines (18). Based on the algorithm, once it is determined that the patient does not require urgent surgery, the clinician should determine the patient's active cardiac conditions (see Table A1) and/or perioperative risk predictor (see Table A2). If any active cardiac conditions and/or major risk predictors are present (see Tables A1 and A2), Figure A1 suggests consideration of coronary angiography and postponing or canceling noncardiac surgery. Once perioperative risk predictors are assessed based on the algorithm, then the surgical risk and patient's functional status should be used to establish the need for noninvasive testing.

Thrombolysis In Myocardial Infarction Risk Scores

The TIMI risk score (21) is a simple tool composed of 7 (1-point) risk indicators rated on presentation (Table A3). The composite end points (all-cause mortality, new or

Table A1. TIMI Risk Score for Unstable Angina/ Non–ST-Elevation Myocardial Infarction

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

*According to Campeau (24). †May include "stable" angina in patients who are unusually sedentary. ‡The American College of Cardiology National Database Library defines recent MI as more than 7 days but less than or equal to 1 month (within 30 days). Reprinted from Anderson et al. (25).

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

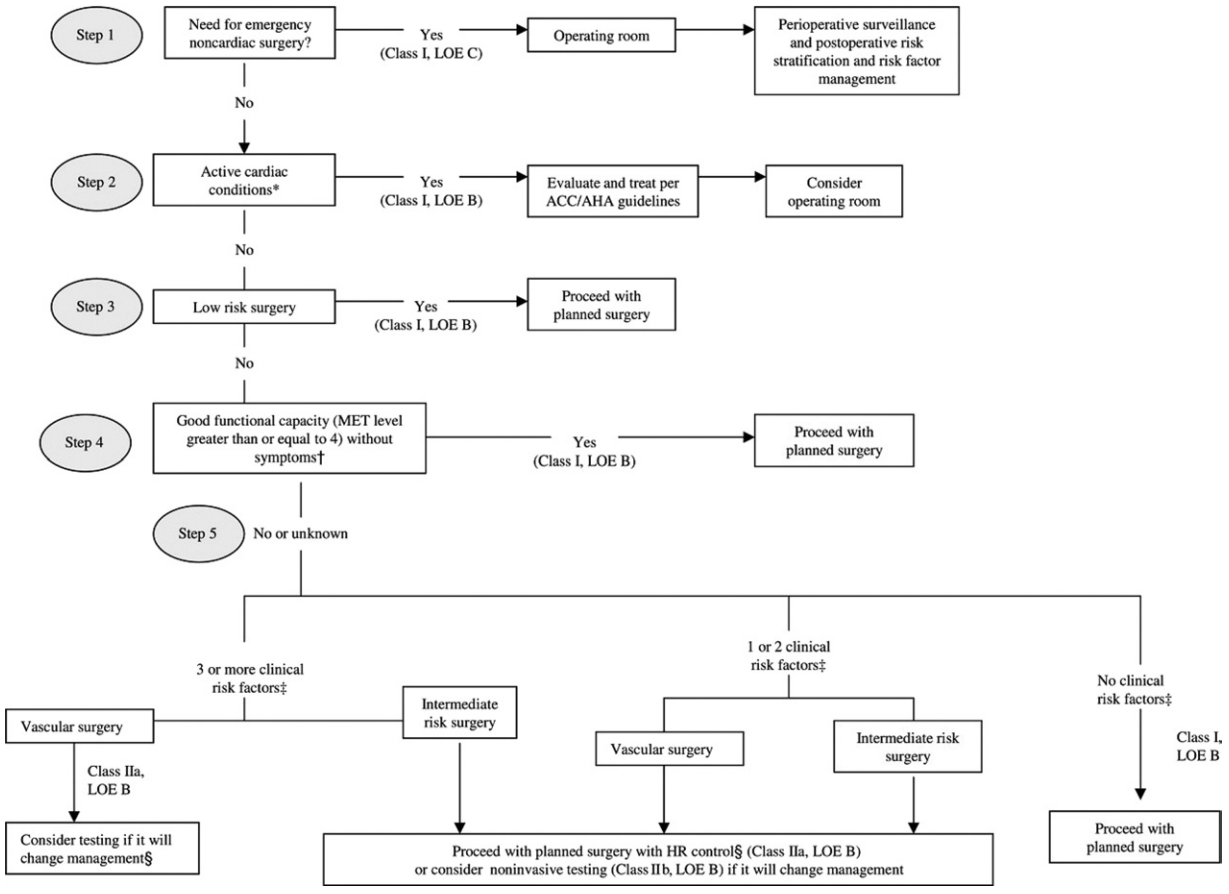

Figure A1. Stepwise Approach to Perioperative Cardiac Assessment

Cardiac evaluation and care algorithm for noncardiac surgery based on active clinical conditions, known cardiovascular disease, or cardiac risk factors for patients 50 years of age or greater. *See Table A1 for active clinical conditions. †Please note that the 2007 ACC/AHA Guidelines for Perioperative Cardiac Assessment recommend that noninvasive testing is not useful for patients with no clinical risk factors undergoing intermediate-risk noncardiac surgery (*Level of Evidence: C*) and that noninvasive testing is not useful for patients undergoing low-risk noncardiac surgery (*Level of Evidence: C*). ‡See Table A2 for list of clinical risk factors. §Noninvasive testing may be considered before surgery in specific patients with risk factors if it will change management. Clinical risk factors include ischemic heart disease, compensated or prior heart failure, diabetes mellitus, renal insufficiency, and cerebrovascular disease. ¶Consider perioperative beta blockade for populations in which this has been shown to reduce cardiac morbidity/mortality. Reprinted from the recommendations from the ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery (18).

recurrent MI, or severe recurrent ischemia prompting urgent revascularization within 14 days) increase as the TIMI risk score increases. The model remained a significant predictor of events and test sensitivity and was relatively unaffected/uncompromised by missing information, such as knowledge of previously documented coronary stenosis of 50% or more. The model's predictive ability remained intact with a cutoff of 65 years of age.

The TIMI risk score is determined by the sum of the presence of 7 variables at admission; 1 point is given for each of the following variables: age 65 years or older; at least 3 risk factors for CAD; prior coronary stenosis of 50% or more; ST-segment deviation on ECG presentation; at least 2 anginal events in prior 24 hours; use of aspirin in prior 7 days; and elevated serum cardiac biomarkers. Prior coronary

Table A2. Perioperative Clinical Risk Factors*

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

*As defined by the ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery (18). Note that these are *not* standard CAD risk factors.

Table A3. Active Cardiac Conditions for Which the Patient Should Undergo Evaluation and Treatment Before Noncardiac Surgery (Class I, Level of Evidence: B)

TIMI Risk Score	All-Cause Mortality, New or Recurrent MI, or Severe Recurrent Ischemia Requiring Urgent Revascularization Through 14 Days After Randomization, %
0–1	4.7
2	8.3
3	13.2
4	19.9
5	26.2
6–7	40.9

Reprinted from the recommendations from the ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery (18).

stenosis of 50% or more was relatively unaffected/uncompromised by missing information and remained a significant predictor of events.

Low-Risk TIMI Score: TIMI score less than 2‡

High-Risk TIMI Score: TIMI score greater than or equal to 2

ECG—Uninterpretable

Refers to ECGs with resting ST-segment depression (greater than or equal to 0.10 mV), complete LBBB, preexcitation (Wolff-Parkinson-White Syndrome), or paced rhythm.

Appendix B: Additional Methods

See Section 2, Methods, for a description of panel selection, indication development, scope of indications, and rating process.

Relationships With Industry

The ACCF and its partnering organizations rigorously avoid any actual, perceived, or potential conflicts of interest that might arise as a result of an outside relationship or personal interest of a member of the technical panel. Specifically, all 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 AUC Working Group, discussed with all members of the technical panel at the face-to-face meeting, and updated and reviewed as necessary. A table of disclosures by the technical panel and oversight working group members can be found in Appendix C.

Literature Review

The technical panel members were asked to refer to the relevant guidelines for a summary of the relevant literature, guideline recommendation tables, and reference lists provided for each indication table when completing their ratings (Online Appendix at http://content.onlinejacc.org/cgi/content/full/j.jacc.2009.02.013).

Appendix C: ACCF Appropriate Use Criteria for Cardiac Radionuclide Imaging Participants

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‡The use of TIMI score of 2 as a cut-point was arbitrary, but the technical panel felt the need to establish a threshold.

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

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This table represents the relevant relationships of committee members with industry and other entities that were reported orally at the initial writing committee meeting and updated in conjunction with all meetings and conference calls of the writing committee during the document development process. It does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of 5% or more of the voting stock or share of the business entity, or ownership of $10 000 or more of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. A relationship is considered to be modest if it is less than significant under the preceding definition. Relationships in this table are modest unless otherwise noted.

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Key Words: ACCF Appropriate Use Criteria ■ cardiac radionuclide imaging ■ SPECT MPI ■ PET ■ coronary artery disease ■ cardiac imaging ■ diagnostic testing.

APPENDIX

Supplementary materials cited in this article are available online.

ACCF/ASNC/ACR/AHA/ASE/SCCT/SCMR/SNM 2009 Appropriate Use Criteria for Cardiac Radionuclide Imaging: A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the American Society of Nuclear Cardiology, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the Society of Cardiovascular Computed Tomography, the Society for Cardiovascular Magnetic Resonance, and the Society of Nuclear Medicine Endorsed by the American College of Emergency Physicians

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