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CARDIAC RADIONUCLIDE IMAGING WRITING GROUP, Robert C. Hendel, Daniel S. Berman, Marcelo F. Di Carli, Paul A. Heidenreich, Robert E. Henkin, Patricia A. Pellikka, Gerald M. Pohost and Kim A. Williams

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

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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 appropriate use of cardiovascular imaging for selected patient indications.

Appropriate use criteria publications reflect an ongoing effort by the ACCF to critically and systematically create,

review, and categorize clinical situations where diagnostic tests and procedures are utilized by physicians caring for patients with cardiovascular diseases. The process is based on 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 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 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.

*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).

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]

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 Electrocardiogram (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 literature review.[13] Please refer to definitions

†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.

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)**

(*Continued*)

Table 1. Continued

Indication		Appropriate Use Score (1–9)
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)**

(*Continued*)

Table 3. Continued

Indication		Appropriate Use Score (1–9)
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)**

(*Continued*)

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)**

(*Continued*)

Table 11. Continued

	Indication	Appropriate Use Score (1–9)
	Risk Assessment: Within 3 Months of an ACS **ACS–Asymptomatic Postrevascularization (PCI or CABG)**	
53.	• Evaluation prior to hospital discharge	**I (1)**
	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 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

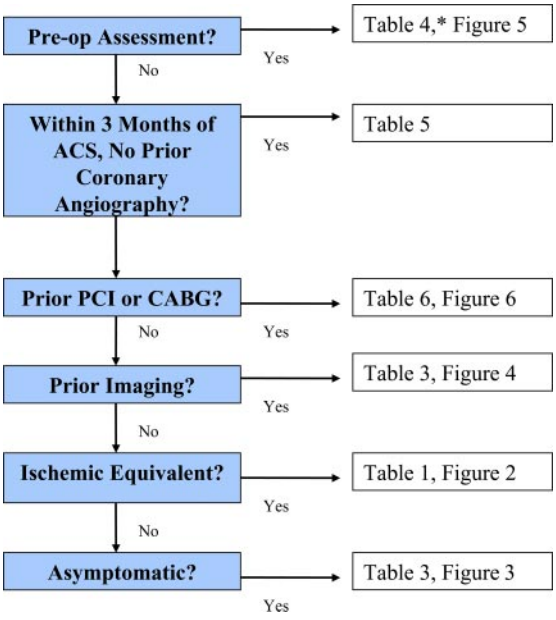

Figure 1. Hierarchy of Potential Test Ordering Based on Clinical Presentation. For those patients who may be classified into more than 1 of the clinical indication tables and/or algorithms, this flow chart places clinical conditions into a hierarchy to aid in assessing appropriateness for radionuclide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

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.

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 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

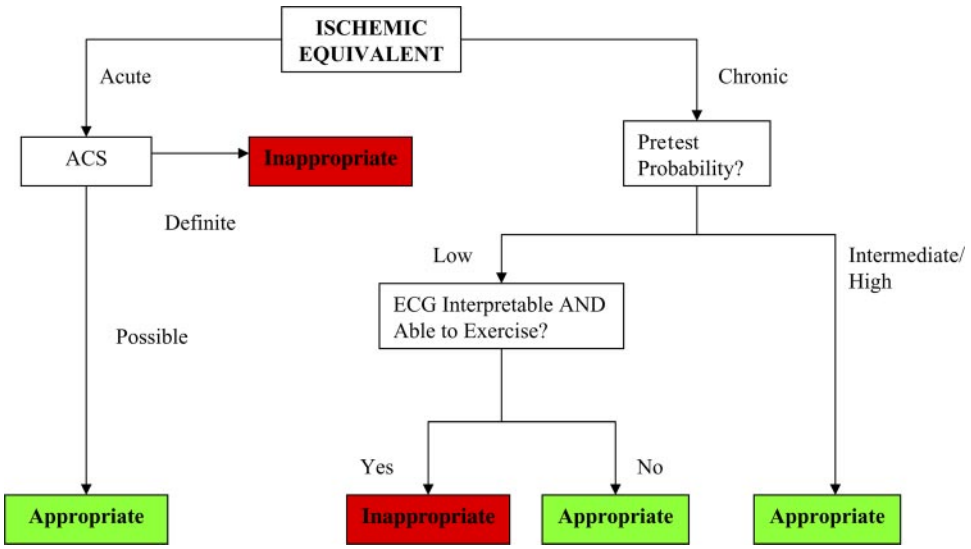

Figure 2. Potential Applications for Chest Pain. Patients with an ischemic equivalent, consisting of symptoms associated with CAD or ECG findings, were divided based on the likelihood of CAD. If patients had an intermediate or high likelihood for CAD, RNI was appropriate. RNI was also appropriate for 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.

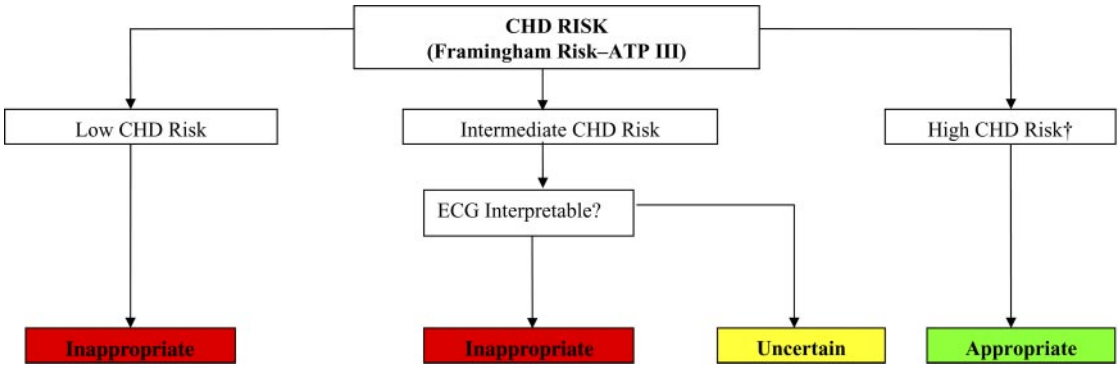

Figure 3. Potential Applications for Asymptomatic* Patients. Only in high CHD risk patients was RNI felt to be appropriate, although those with intermediate CHD risk with an uninterpretable ECG were uncertain. The presence of syncope did not alter the appropriateness of patients separate from their CHD 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).

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 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

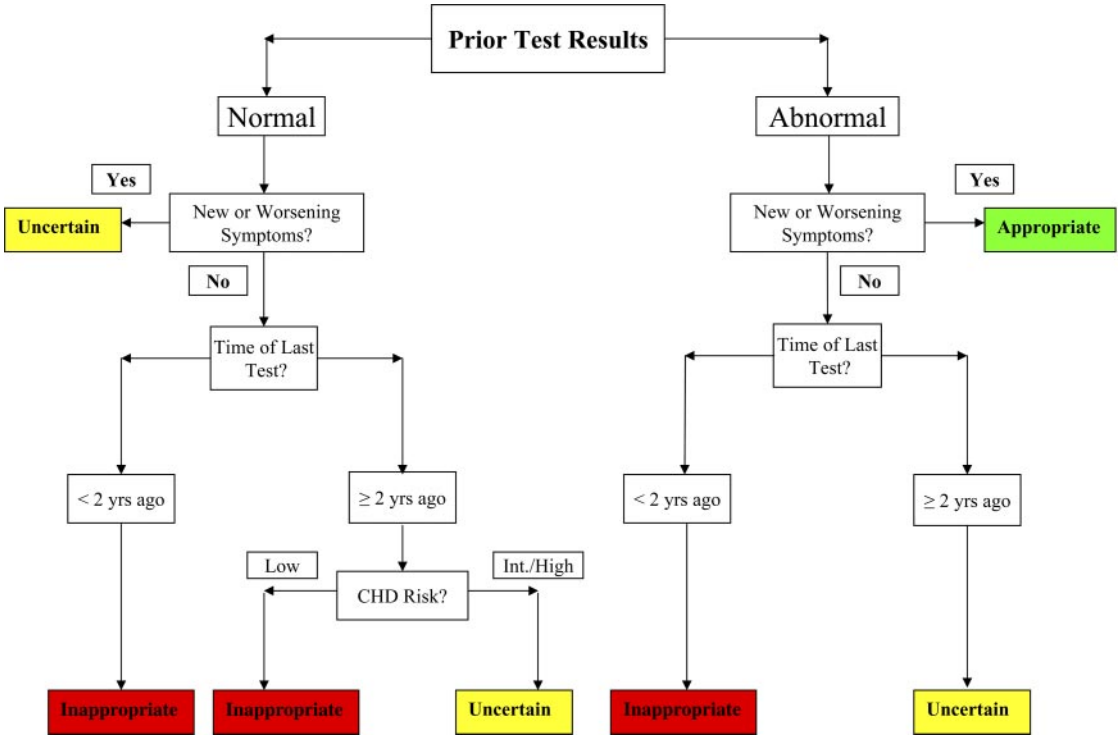

Figure 4. Prior Test Results.* When new or worsening symptoms were present, RNI was appropriate if prior abnormal results were present, but was uncertain if the prior study was normal. RNI was inappropriate when no or stable symptoms were present if prior test results were known, except when performed 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.

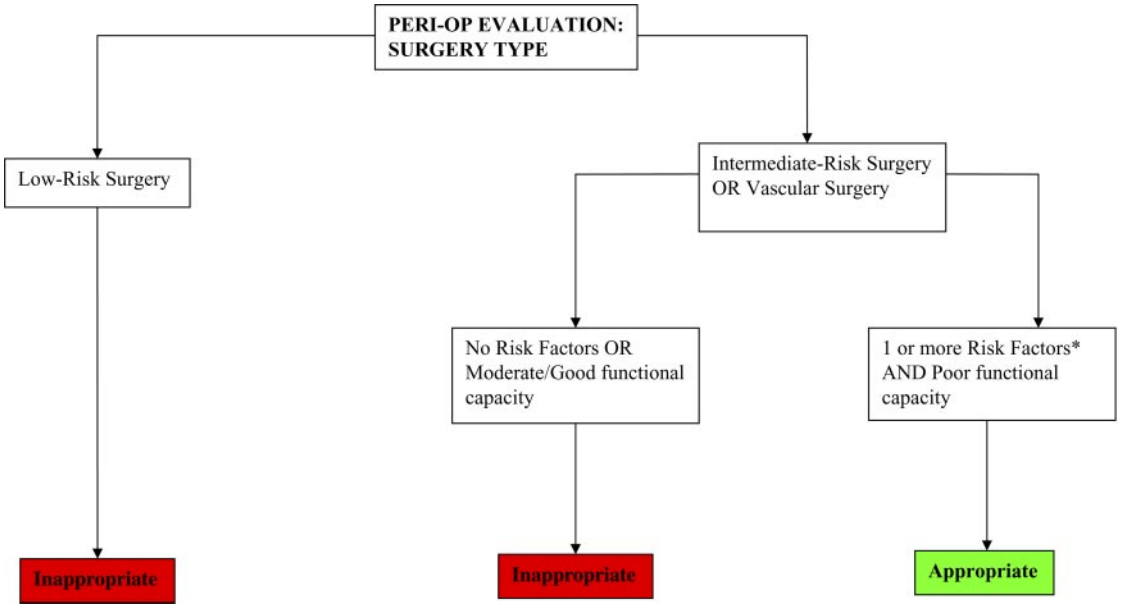

Figure 5. Perioperative Evaluation. RNI was felt to be inappropriate for preoperative risk assessment except in the setting of intermediate risk or vascular surgery when at least 1 risk factor is present and the patient has poor or unknown functional capacity. Additionally, patients who are asymptomatic 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).

technical panel ultimately decided to remove the distinction due to the lack sufficient evidence that this qualification was relevant.

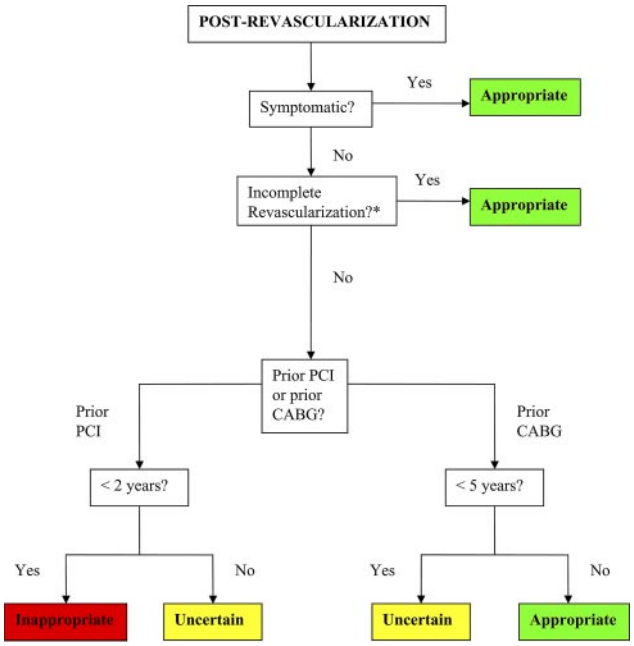

Figure 6. Postrevascularization. Following revascularization with PCI or CABG in a more chronic (>3 months) setting, recurrence of symptoms or the presence of suspected incomplete revascularization were felt to be appropriate indications for RNI. For asymptomatic patients less than 2 years after a PCI, 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.

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 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.

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References

1. Brindis RG, Douglas PS, Hendel RC, et al. ACCF/ASNC appropriateness criteria for single-photon emission computed tomography myocardial perfusion imaging (SPECT MPI): a report of the American College of Cardiology Foundation Strategic Direction Committee Appropriateness Criteria Working Group and the American Society of Nuclear Cardiology. J Am Coll Cardiol. 2005;46:1587–605.
2. Douglas PS, Khandheria B, Stainback RF, et al. ACCF/ASE/ACEP/AHA/ASNC/SCAI/SCCT/SCMR 2008 appropriateness criteria for stress echocardiography. J Am Coll Cardiol. 2008;51:1127–47.
3. Hendel RC, Patel MR, Kramer CM, et al. ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR 2006 appropriateness criteria for cardiac computed tomography and cardiac magnetic resonance imaging. J Am Coll Cardiol. 2006;48:1475–97.
4. Patel MR, Spertus JA, Brindis RG, et al. ACCF proposed method for evaluating the appropriateness of cardiovascular imaging. J Am Coll Cardiol. 2005;46:1606–13.
5. Fitch K, Bernstein, SJ, Aguilar, MD, et al. The RAND/UCLA Appropriateness Method User's Manual. Arlington, Va: RAND; 2001.
6. Ficaro E. Imaging guidelines for nuclear cardiology procedures. J Nucl Cardiol. 2006;13:888.
7. Gibbons RJ, Balady GJ, Bricker JT, et al. ACC/AHA 2002 guideline update for exercise testing: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1997 Exercise Testing Guidelines). J Am Coll Cardiol. 2002;40:1531–40.
8. National Institutes of Health: National Heart, Lung, and Blood Institute. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). NIH Publication No. 02-5215. September 2002.
9. Grundy SM, Pasternak R, Greenland P, et al. AHA/ACC scientific statement: assessment of cardiovascular risk by use of multiple-risk factor assessment equations: a statement for healthcare professionals from the American Heart Association and the American College of Cardiology. J Am Coll Cardiol. 1999;34:1348–59.
10. Morise AP, Haddad WJ, Beckner D. Development and validation of a clinical score to estimate the probability of coronary artery disease in men and women presenting with suspected coronary disease. Am J Med. 1997;102:350–6.
11. Pryor DB, Shaw L, McCants CB, et al. Value of the history and physical in identifying patients at increased risk for coronary artery disease. Ann Intern Med. 1993;118:81–90.
12. Gibbons RJ, Abrams J, Chatterjee K, et al. ACC/AHA 2002 guideline update for the management of patients with chronic stable angina—summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee on the Management of Patients With Chronic Stable Angina). J Am Coll Cardiol. 2003;41:159–68.
13. Diamond GA, Forrester JS. Analysis of probability as an aid in the clinical diagnosis of coronary-artery disease. N Engl J Med. 1979;300:1350–8.
14. Gibbons RJ, Balady GJ, Bricker JT, et al. ACC/AHA 2002 guideline update for exercise testing: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1997 Exercise Testing Guidelines). J Am Coll Cardiol. 2002;40:1531–40.
15. Mehta R, Agarwal S, Chandra S, Ward RP, Williams KA. Evaluation of the American College of Cardiology Foundation/American Society of Nuclear Cardiology Appropriateness Criteria for SPECT Myocardial Perfusion Imaging, J Nucl Cardiol. 2008;15:337–44.
16. Gibbons RJ, Miller TD, Hodge D, et al. Application of appropriateness criteria to stress single-photon emission computed tomography sestamibi studies and stress echocardiograms in an academic medical center. J Am Coll Cardiol. 2008;51:1283–9.
17. Ward RP, Al-Mallah MH, Grossman GB, et al. American Society of Nuclear Cardiology review of the ACCF/ASNC Appropriateness Criteria for Single-Photon Emission Computed Tomography Myocardial Perfusion Imaging (SPECT MPI). J Nucl Cardiol. 2007;14:e26–38.
18. Fleisher LA, Beckman JA, Brown KA, et al. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). J Am Coll Cardiol. 2007;23;50:e159–241.
19. Douglas, P, Iskandrian, AE, Krumholz, HM, et al. Achieving quality in cardiovascular imaging: proceedings from the American College of Cardiology-Duke University Medical Center Think Tank on Quality in Cardiovascular Imaging. J Am Coll Cardiol. 2006;48:2141–51.
20. Antman EM, Cohen M, Bernink PJ, et al. The TIMI risk score for unstable angina/non-ST elevation MI: a method for prognostication and therapeutic decision making. JAMA. 2000;284:835–42.
21. Askew JW, Miller TD, Hodge DO, Gibbons RJ. The value of myocardial perfusion single-photon emission computed tomography in screening asymptomatic patients with atrial fibrillation for coronary artery disease. J Am Coll Cardiol. 2007;50:1080–5.
22. Bierig SM, Ehler D, Knoll ML, Waggoner AD. American Society of Echocardiography minimum standards for the cardiac sonographer: a position paper. J Am Soc Echocardiogr. 2006;19:471–4.
23. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction—executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 1999 Guidelines for the Management of Patients With Acute Myocardial Infarction). J Am Coll Cardiol. 2004;44:671–719.
24. Campeau L. Letter: grading of angina pectoris. Circulation. 1976;54:522–3.
25. Anderson JL, Adams CD, Antman EM, et al. ACC/AHA 2007 guidelines for the management of patients with unstable angina/non–ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines for the Management of Patients With Unstable Angina/Non–ST-Elevation Myocardial Infarction). J Am Coll Cardiol. 2007;50:e1–157.

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.

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 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.

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)

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.

*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]

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

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.

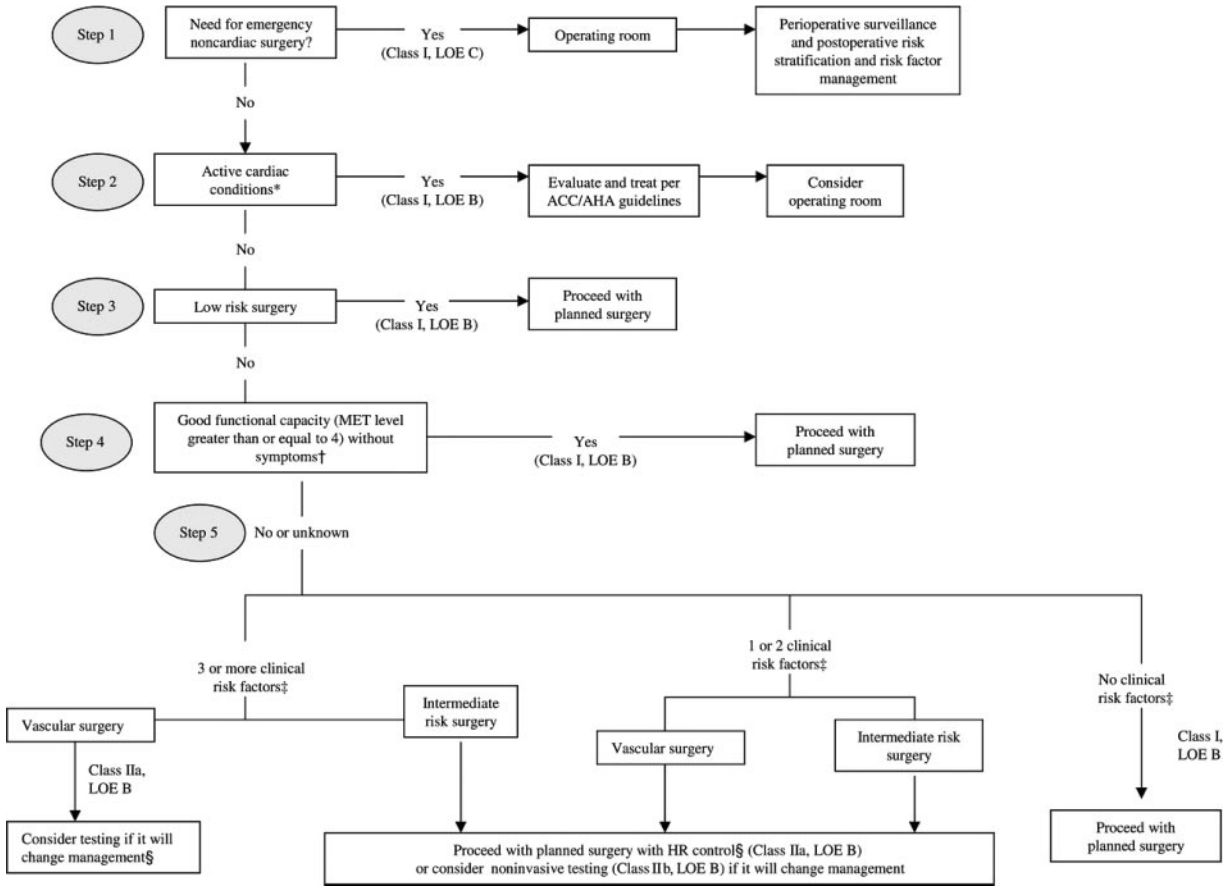

Figure A1. Stepwise Approach to Perioperative Cardiac Assessment. Cardiac evaluation and care algorithm for noncardiac surgery based on active clinical conditions, known cardiovascular disease, or cardiac risk factors for patients 50 years of age or greater. *See Table A1 for active clinical conditions. †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]

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]

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.

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

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://circ.ahajournals.org/cgi/content/full/CIRCULATIONAHA.109.192519/DC1).

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

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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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Dr. Daniel S. Berman	• Astellas • Floura Pharma • Tyco Mallinckrodt Healthcare	None	• Cedars Sinai Medical Center • Spectrum Dynamics	• Astellas • Bristol-Myers Squibb Medical Imaging • Siemens • Tyco Mallinckrodt Healthcare	None	None
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Dr. Gerald M. Pohost	None	None	None	None	None	None
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Cardiac Radionuclide Imaging Appropriate Use Criteria Technical Panel						
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Dr. Timothy M. Bateman	• Astellas • CV Therapeutics • Bracco Diagnostics • Lantheus • Molecular Insights Pharmaceuticals • Spectrum Dynamics	None	• CVIT	• Bracco Diagnostics • Philips Medical Systems	None	None
Dr. Manuel D. Cerqueira	• Astellas • CV Therapeutics • GE Healthcare • Siemens	• Astellas • CardiArc • Covidien • GE Healthcare	None	• CardiArc • Perceptive Informatics	None	• Intellectual property rights
Dr. James R. Corbett	None	None	None	None	None	None
Dr. Anthony J. Dean	None	None	None	• In-kind support with institutional loan of ultrasound equipment	None	None

(*Continued*)

Appendix D. Continued

Committee Member	Consultant	Speaker	Ownership/ Partnership/ Principal	Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Dr. Gregory J. Dehmer	None	None	None	None	None	• Evaluation of PCI program • Fair hearing related to physician privileges at hospital • Need for open heart surgery for facility
Dr. Peter Goldbach	None	• MedVantange, Inc.	None	None	• Blue Cross Blue Shield of Massachusetts (Medical Director, former) • MedVantange, Inc. (Chief Executive Officer)	None
Dr. Leonie Gordon	None	None	None	None	None	• PET brain scan
Dr. Frederick G. Kushner	None	None	None	• AstraZeneca • Novartis • Pfizer	None	None
Dr. Raymond Y. Kwong	None	None	None	None	None	None
Dr. James Min	• GE Healthcare	• GE Healthcare	None	None	None	None
Dr. Miguel A. Quinones	None	None	None	None	None	• Diet pills and valve disease
Dr. R. Parker Ward	None	None	None	• Pfizer	None	None
Dr. Michael J. Wolk	None	None	None	None	None	None
Dr. Scott H. Yang	None	None	None	None	None	None
Cardiac Radionuclide Imaging Appropriate Use Criteria Task Force						
Mr. Joseph M. Allen	None	None	None	None	None	None
Dr. Ralph G. Brindis	None	None	None	None	None	None
Dr. Pamela S. Douglas	• BG Medicine • Expression Analysis • Genentech • GlaxoSmithKline Foundation • Northpoint Domain • Ortho Diagnostics • Pappas Ventures • Visen Medicad • Xceed Molecular	None	• CardioDX • Millennium • Northpoint Domain	• Atritech • Edwards Lifesciences • Lab Corp • Reata • United Health Care	None	None

(*Continued*)

Appendix D. Continued

Committee Member	Consultant	Speaker	Ownership/ Partnership/ Principal	Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Dr. Robert C. Hendel	• Astellas • GE Healthcare • PGx Health	• Astellas	None	• GE Healthcare	None	None
Dr. Manesh R. Patel	None	None	None	None	None	None
Dr. Eric D. Peterson	None	None	None	• Bristol-Myers Squibb/ Sanofi Aventis • Merck • Schering-Plough • St. Jude	None	None
Dr. Michael J. Wolk	None	None	None	None	None	None
Cardiac Radionuclide Imaging Appropriate Use Criteria Indication Reviewers						
Dr. James Arrighi	None	None	None	None	None	None
Dr. Robert O. Bonow	• Bristol-Myers Squibb Medical Imaging • Edwards Lifesciences	None	None	None	None	None
Dr. Lee A. Fleisher	None	None	None	None	None	• Preoperative potassium • Preoperative potassium level
Dr. Julius M. Gardin	None	• CV Therapeutics • Pfizer • Takeda	None	• Merck	None	None
Dr. Raymond J. Gibbons	• Cardiovascular Clinical Studies (WOMEN study) • Consumers Union • TIMI 37A	None	None	• Kai Pharmaceuticals • King Pharmaceuticals • Radiant Medical • TargeGen • Ther Ox	None	None
Dr. John A. Gillespie	None	None	None	None	None	None
Dr. Bennett S. Greenspan	None	None	None	None	None	None
Dr. Rory Hachamovitch	• Bristol-Myers Squibb Medical Imaging	• GE Healthcare	None	• Astellas • Bracco Diagnostics • GE Healthcare • Siemens	None	None
Dr. Warren R. Janowitz	None	None	None	None	None	None
Dr. Christopher M. Kramer	• Siemens	None	None	• Astellas • GlaxoSmithKline • Merck • Siemens	None	None

(*Continued*)

Appendix D. Continued

Committee Member	Consultant	Speaker	Ownership/ Partnership/ Principal	Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Dr. Michael H. Picard	• Acusphere	None	None	• Edwards Lifesciences	None	None
Dr. Michael Poon	None	None	None	None	None	None
Dr. Miguel A. Quinones	None	None	None	None	None	• Diet pills and valve disease
Dr. Raymond F. Stainback	None	None	None	None	None	None
Dr. Mark I. Travin	None	None	None	None	None	• Adding exercise to pharmacologic stress • ECG stress testing and ordering nuclear studies
Dr. Samuel Wann	None	None	None	None	None	None
Dr. R. Parker Ward	None	None	None	• Pfizer	None	None
Dr. Neil J. Weissman	• Takeda • Wyeth	None	None	• Acusphere • Arena Pharmaceutical • ATS • Biotronik • Boston Scientific • Edwards Lifesciences • Lipid Science • Point Biomedical • Sorin Carbomedics • Spectranetics • St. Jude • Zilver	None	• Anorexic agents
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Dr. William A. Zoghbi	None	None	None	None	None	None

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.

Appropriate Use Criteria for Cardiac Radionuclide Imaging Ratings
Moderator

	Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Table 1. Detection of CAD: Symptomatic																					
Evaluation of Ischemic Equivalent (Non-Acute)																					
1	• Low pre-test probability of CAD • ECG interpretable AND able to exercise	4	2	1	5	1	3	4	2	1	5	3	2	4	3	3	3	1.1	I		
2	• Low pre-test probability of CAD • ECG uninterpretable OR unable to exercise	9	7	3	9	5	7	6	7	7	8	8	8	7	7	5	7	1.1	A	+	
3	• Intermediate pre-test probability of CAD • ECG interpretable AND able to exercise	9	7	2	8	1	7	3	7	8	8	8	7	7	7	7	7	1.4	A	+	
4	• Intermediate pre-test probability of CAD • ECG uninterpretable OR unable to exercise	9	9	8	9	7	8	9	9	9	9	9	9	9	9	9	9	0.3	A	+	
5	• High pre-test probability of CAD • Regardless of ECG interpretability and ability to exercise	9	9	5	9	5	8	6	8	7	5	8	7	6	8	9	8	1.3	A		
Acute Chest Pain																					
6	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically paced ventricular rhythm • Low-Risk TIMI Score • Peak Troponin: borderline, equivocal, minimally elevated	9	9	8	8	7	8	7	8	3	8	7	8	7	8	6	8	0.9	A	+	
7	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically paced ventricular rhythm • High-Risk TIMI Score • Peak Troponin: borderline, equivocal, minimally elevated	9	8	1	9	2	8	5	8	1	7	7	7	5	8	9	7	2.1	A		
8	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically paced ventricular rhythm • Low-Risk TIMI Score • Negative troponin levels	9	8	9	9	3	7	3	8	8	8	7	8	8	7	4	8	1.3	A	+	
9	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically paced ventricular rhythm • High-Risk TIMI Score • Negative troponin levels	9	9	8	9	7	5	7	9	1	8	6	7	8	8	8	8	1.3	A	+	
10	• Definite ACS	1	1	1	3	1	2	1	1	1	1	1	1	1	2	2	1	0.3	I	+	
Acute Chest Pain (Rest Imaging Only)																					
11	• Possible ACS • ECG—no ischemic changes or with LBBB or electronically paced ventricular rhythm • Initial troponin negative • Recent or on-going chest pain	9	9	7	7	7	2	6	8	9	2	8	6	8	8	6	7	1.5	A		
Table 2. Detection of CAD/Risk Assessment Without Chest Pain Syndrome																					
Asymptomatic																					
12	• Low CHD risk (ATP III risk criteria)	1	1	1	2	1	2	1	1	1	1	1	1	2	1	1	1	0.2	I	+	
13	• Moderate CHD risk (ATP III risk criteria) • ECG uninterpretable	7	3	3	5	1	4	4	3	1	5	1	4	3	3	3	3	1.1	I		
14	• Moderate CHD risk (ATP III risk criteria) • ECG uninterpretable	9	3	7	8	1	4	4	6	1	5	5	7	5	7	6	5	1.8	U		
15	• High CHD risk (ATP III risk criteria)	9	7	9	9	1	7	6	8	3	5	7	7	7	7	7	7	1.3	A	+	
New-Onset or Newly Diagnosed Heart Failure with LV Systolic Dysfunction Without Ischemic Equivalent																					
16	• No prior CAD evaluation AND no planned coronary angiography	9	9	8	9	3	7	7	8	9	8	8	8	8	8	8	8	0.7	A	+	
New-Onset Atrial Fibrillation																					
17	• Part of evaluation when etiology unclear	9	7	4	8	3	5	5	7	3	7	6	7	6	5	7	6	1.4	U		
Ventricular Tachycardia																					
18	• Low CHD risk (ATP III risk criteria)	7	7	8	8	3	4	5	6	8	1	8	7	8	7	7	7	1.4	A		
19	• Moderate or High CHD risk (ATP III risk criteria)	9	8	9	9	3	7	3	8	6	7	8	9	9	9	9	8	1.4	A	+	
Syncope																					
20	• Low CHD risk (ATP III risk criteria)	3	3	5	5	1	5	4	1	5	1	2	5	1	2	3	3	1.4	I		
21	• Moderate or High CHD risk (ATP III risk criteria)	6	8	8	8	3	5	7	7	8	7	8	7	6	8	6	7	1.0	A		

	Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Elevated Troponin																					
22	• Troponin elevation without additional evidence of acute coronary syndrome	9	8	8	8	7	6	7	8	7	7	7	7	7	7	6	7	0.5	A	+	
Table 3. Risk Assessment With Prior Test Results and/or Known Chronic Stable CAD																					
Asymptomatic OR Stable Symptoms Normal Prior Stress Imaging Study (SPECT or Echocardiography)																					
23	• Low CHD risk (ATP III risk criteria) • Last stress imaging study done less than 2 years ago	5	1	3	2	1	7	2	1	1	1	1	1	2	1	2	1	1.1	I	+	
24	• Intermediate to High CHD risk (ATP III risk criteria) • Last stress imaging study done less than 2 years ago	7	1	3	3	1	6	2	3	1	1	3	4	2	2	6	3	1.5	I	+	
25	• Low CHD risk (ATP III risk criteria) • Last stress imaging study done more than 2 years ago	7	2	6	5	1	3	2	3	1	1	3	3	4	2	3	3	1.3	I	+	
26	• Intermediate to High CHD risk (ATP III risk criteria) • Last stress imaging study done more than 2 years ago	9	5	8	8	1	6	2	7	1	2	3	6	7	6	7	6	2.1	U		-
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	8	2	8	3	1	3	2	5	1	1	2	3	5	4	4	3	1.7	I		
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	9	7	9	8	2	3	2	8	1	2	3	5	5	6	7	5	2.4	U		-
Poor non-invasive evaluation																					
29	• Equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern	9	9	8	9	7	7	7	9	8	8	8	8	9	8	7	8	0.6	A	+	
New or Worsening Symptoms																					
30	• Abnormal coronary angiography OR abnormal prior stress imaging study	9	9	2	9	7	7	8	9	9	8	8	8	9	9	9	9	1.0	A	+	
31	• Normal coronary angiography OR normal prior stress imaging study	9	7	5	7	7	5	5	7	8	5	6	5	6	6	6	6	0.9	U		
Coronary Angiography (Invasive or Noninvasive)																					
32	• Coronary stenosis or anatomic abnormality of uncertain significance.	9	9	8	9	9	8	7	9	9	8	7	8	9	9	8	9	0.6	A	+	
Asymptomatic Prior Coronary Calcium Agatston Score																					
33	• Agatston score less than 100	2	2	2	1	1	2	2	1	1	2	1	2	3	1	1	2	0.5	I	+	
34	• High CHD risk (ATP III risk criteria) • Agatston score between 100-400	7	6	7	6	1	4	4	5	1	5	3	6	6	6	4	5	1.5	U		
35	• Low to Intermediate CHD risk (ATP III risk criteria) • Agatston score between 100-400	8	7	7	8	1	6	3	8	2	5	3	7	8	7	7	7	1.7	A		
36	• Agatston score greater than 400	9	8	8	8	3	5	4	9	7	5	7	8	9	7	7	7	1.4	A	+	
Duke Treadmill Score, Asymptomatic																					
37	• Low-Risk Duke treadmill score	4	1	2	2	1	2	2	2	1	2	2	2	2	2	3	2	0.4	I	+	
38	• Intermediate-Risk Duke treadmill score	9	7	7	8	7	4	7	6	7	8	6	8	5	7	7	7	0.8	A	+	
39	• High-Risk Duke treadmill score	8	8	8	9	3	8	7	8	6	2	7	7	8	7	8	8	1.2	A	+	
Table 4. Risk Assessment: Preoperative Evaluation for Non-Cardiac Surgery																					
Low-Risk Surgery, no active cardiac condition																					
40	• Preoperative evaluation for non-cardiac surgery risk assessment	1	1	3	2	1	2	4	1	1	1	1	1	2	1	1	1	0.5	I	+	
Intermediate-Risk Surgery, no active cardiac condition																					
41	• Moderate to Good functional capacity (greater than or equal to 4 METs)	4	1	4	4	1	3	3	3	1	1	2	4	3	3	3	3	0.9	I	+	
42	• No clinical risk factors	1	1	4	2	1	3	3	1	1	1	1	3	3	2	2	2	0.9	I	+	
43	• Greater than or equal to 1 clinical risk factor • Poor or unknown functional capacity (less than 4 METs)	8	8	8	8	4	7	4	8	8	6	6	8	6	7	7	7	1.1	A		
44	• Asymptomatic up to 1 year post normal catheterization, non-invasive test, or previous revascularization	4	1	3	2	1	2	4	1	1	1	1	2	1	2	2	2	0.8	I	+	
Vascular Surgery, no active cardiac condition																					
45	• Moderate to Good functional capacity (greater than or equal to 4 METs)	3	2	5	6	1	4	3	3	4	1	1	4	6	3	3	3	1.2	I		
46	• No clinical risk factors	3	2	4	2	1	1	3	1	1	1	1	3	5	1	2	2	1.0	I	+	
47	• Greater than or equal to 1 clinical risk factor • Poor or unknown functional capacity (less than 4 METs)	9	9	8	9	7	4	7	8	9	8	7	8	8	7	7	8	0.9	A	+	
48	• Asymptomatic up to 1 year post normal catheterization, non-invasive test, or previous revascularization	5	1	3	2	1	3	4	1	1	1	1	2	3	2	2	2	0.9	I	+	

	Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Table 5. Risk Assessment: Within 3 Months of an Acute Coronary Syndrome																					
STEMI																					
49	• Primary PCI with complete revascularization • No recurrent symptoms	3	1	1	5	1	2	2	1	1	1	1	2	5	3	4	2	1.1	I	+	
50	• Hemodynamically stable, no recurrent chest pain symptoms or no signs of HF • To evaluate for inducible ischemia • No prior coronary angiography	9	9	9	9	9	5	2	9	8	2	7	9	8	7	7	8	1.7	A	+	
51	• Hemodynamically unstable, signs of cardiogenic shock, or mechanical complications	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	0.1	I	+	
UA/NSTEMI																					
52	• Hemodynamically stable, no recurrent chest pain symptoms or no signs of HF • To evaluate for inducible ischemia • No prior coronary angiography	9	9	9	9	9	7	2	9	8	8	8	9	9	9	2	9	1.3	A	+	
ACS- Asymptomatic Post Revascularization (PCI or CABG)																					
53	• Evaluation prior to hospital discharge	1	1	1	2	1	3	2	1	1	1	2	1	2	1	2	1	0.5	I	+	
Cardiac Rehabilitation																					
54	• Prior to initiation of cardiac rehabilitation (as a stand-alone indication)	7	5	2	7	1	7	2	1	5	1	2	2	3	3	3	3	1.7	I		
Table 6. Risk Assessment: Post-Revascularization (PCI or CABG)																					
Symptomatic																					
55	• Evaluation of ischemic equivalent	9	9	9	9	7	8	7	9	9	8	7	8	9	8	8	8	0.7	A	+	
Asymptomatic																					
56	• Incomplete revascularization • Additional revascularization feasible	8	8	9	8	5	8	5	7	6	8	6	6	9	6	7	7	1.1	A		
57	• Less than 5 years after CABG	7	5	7	5	1	6	4	5	1	1	6	3	3	6	6	5	1.7	U		
58	• Greater than or equal to 5 years after CABG	9	7	9	8	3	6	4	8	1	1	7	6	7	7	8	7	1.9	A		
59	• Less than 2 years after PCI	7	5	3	3	1	6	4	3	1	1	3	2	3	6	5	3	1.5	I		
60	• Greater than or equal to 2 years after PCI	9	7	6	8	3	5	4	7	1	1	7	4	5	7	8	6	2.0	U		
Cardiac Rehabilitation																					
61	• Prior to initiation of cardiac rehabilitation (as a stand-alone indication)	7	5	2	6	1	6	5	1	1	2	2	3	3	5	3	3	1.7	I		
Table 7. Assessment of Viability/Ischemia																					
Ischemic Cardiomyopathy/Assessment of Viability																					
62	• Known severe LV dysfunction • Patient eligible for revascularization	9	9	9	9	7	8	7	9	9	2	8	9	9	9	9	9	0.9	A	+	
Table 8. Assessment of Viability/Ischemia																					
Evaluation of Left Ventricular Function																					
63	• Assessment of LV function with radionuclide angiography (ERNA or FP (first pass) RNA) • In absence of recent diagnostic information regarding ventricular function obtained with another imaging modality	9	8	3	9	7	8	5	9	9	8	8	8	6	9	5	8	1.3	A	+	
64	• Routine use of rest/stress ECG-gating with SPECT or PET myocardial perfusion imaging	9	9	9	9	9	8	9	9	1	9	7	7	6	9	9	9	1.1	A	+	
65	• Routine use of stress FP RNA in conjunction with rest/stress gated SPECT MPI • Detection of multi-vessel CAD	1	1	1	1	3	3	2	5	1	2	3	6	6	3	3	3	1.3	I		
66	• Selective use of stress FP RNA in conjunction with rest/stress gated SPECT MPI • Borderline, mild, or moderate stenoses in three vessels OR moderate or equivocal left main stenosis in left dominant system	7	7	5	7	5	5	2	8	9	6	5	7	6	3	7	6	1.4	U	+	
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	9	9	9	9	7	7	4	9	7	6	7	9	9	9	8	9	1.1	A	+	

# of Appropriate Indications (INLCUDES TEST)	33
# of Uncertain Indications	9
# of Inappropriate Indications	25
	67
# of Indications with Agreement	41
# of Indications with Disgreement	2
# of Indications with Neither Agreement nor Disagreement	33

RELEVANT LITERATURE FOR CARDIAC RADIONUCLIDE IMAGING

Table 1. Detection of CAD: Symptomatic

	Indication	Appropriate Use Criteria (Median Score)
	Evaluation of Ischemic Equivalent (Non-Acute)	
1	• Low pre-test probability of CAD • ECG interpretable AND able to exercise	
2	• Low pre-test probability of CAD • ECG uninterpretable OR unable to exercise	
3	• Intermediate pre-test probability of CAD • ECG interpretable AND able to exercise	
4	• Intermediate pre-test probability of CAD • ECG uninterpretable OR unable to exercise	
5	• High pre-test probability of CAD • Regardless of ECG interpretability and ability to exercise	
	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	
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	
8	• Possible ACS • ECG – no ischemic changes or with LBBB or electronically ventricular paced rhythm • Low-risk TIMI score • Negative peak troponin levels	
9	• Possible ACS • ECG – no ischemic changes or with LBBB or electronically ventricular paced rhythm • High-risk TIMI score • Negative peak troponin levels	
10	• Definite ACS*	

	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 on-going chest pain	

I. New Lit Search:

Berman DS, Shaw LJ, Hachamovitch R, Friedman JD, Polk DM, Hayes SW, Thomson LE, Germano G, Wong ND, Kang X, Rozanski A. "Comparative use of radionuclide stress testing, coronary artery calcium scanning, and noninvasive coronary angiography for diagnostic and prognostic cardiac assessment." *Semin Nucl Med*. 2007 Jan;37(1):2-16. Review.

Berman DS, Hachamovitch R, Shaw LJ, Friedman JD, Hayes SW, Thomson LE, Fieno DS, Germano G, Wong ND, Kang X, Rozanski A.. "Roles of nuclear cardiology, cardiac computed tomography, and cardiac magnetic resonance: Noninvasive risk stratification and a conceptual framework for the selection of noninvasive imaging tests in patients with known or suspected coronary artery disease." *J Nucl Med*. 2006 Jul;47(7):1107-18. Review.

Bax JJ, van der Wall EE. "Assessment of coronary artery disease in patients with (a)symptomatic diabetes." *Eur Heart J*. 2006 Mar;27(6):631-2. Epub 2006 Feb 23. No abstract available.

Mieres JH, Shaw LJ, Arai A, Budoff MJ, Flamm SD, Hundley WG, Marwick TH, Mosca L, Patel AR, Quinones MA, Redberg RF, Taubert KA, Taylor AJ, Thomas GS, Wenger NK; Cardiac Imaging Committee, Council on Clinical Cardiology, and the Cardiovascular Imaging and Intervention Committee, Council on Cardiovascular Radiology and Intervention, American Heart Association. "Role of noninvasive testing in the clinical evaluation of women with suspected coronary artery disease: Consensus statement from the Cardiac Imaging Committee, Council on Clinical Cardiology, and the Cardiovascular Imaging and Intervention Committee, Council on Cardiovascular Radiology and Intervention, American Heart Association." *Circulation*. 2005 Feb 8;111(5):682-96. Epub 2005 Feb 1.

Utsunomiya D, Tomiguchi S, Yamashita Y. "Role of cardiac computed tomography in patients with suspected coronary artery disease: interaction with nuclear cardiology. " *Radiat Med.* 2007 Dec;25(10):493-501. Epub 2007 Dec 25.

Miller TD, DiCarli MF. "Nuclear cardiac imaging for the assessment of coronary artery disease in the elderly." *Am J Geriatr Cardiol.* 2007 Nov-Dec;16(6):355-62. Review.

Hacker M, Jakobs T, Matthiesen F, Nikolaou K, Becker C, Knez A, Tiling R. “Combined functional and morphological imaging consisting of gated myocardial perfusion SPECT and 16-detector multislice spiral CT angiography in the noninvasive evaluation of coronary artery disease: first experiences.” *Clin Imaging*. 2007 Sep-Oct;31(5):313-20.

Heijenbrok-Kal MH, Fleischmann KE, Hunink MG. “Stress echocardiography, stress single-photon-emission computed tomography and electron beam computed tomography for the assessment of coronary artery disease: a meta-analysis of diagnostic performance.” *Am Heart J.* 2007 Sep;154(3):415-23.

Travin MI. “Is it possible for myocardial perfusion imaging to avoid missing any patients with high-risk coronary disease?” *J Nucl Cardiol.* 2007 Jul;14(4):492-6. No abstract available.

Stanford W. “Radiologic evaluation of acute chest pain--suspected myocardial ischemia.” *Am Fam Physician*. 2007 Aug 15;76(4):533-7.

Shaw LJ. “Myocardial perfusion imaging in the evaluation of chest pain in the acute care setting: Clinical and economic outcomes.” *J Nucl Cardiol*. 2007 May-Jun;14(3 Suppl):S133-8. Review. No abstract available.

Candell-Riera J, Oller-Martínez G, de León G, Castell-Conesa J, Aguadé-Bruix S. “Yield of early rest and stress myocardial perfusion single-photon emission computed tomography and electrocardiographic exercise test in patients with atypical chest pain, nondiagnostic electrocardiogram, and negative biochemical markers in the emergency department.” *Am J Cardiol*. 2007 Jun 15;99(12):1662-6. Epub 2007 May 4.

Gani F, Jain D, Lahiri A. “The role of cardiovascular imaging techniques in the assessment of patients with acute chest pain.” *Nucl Med Commun.* 2007 Jun;28(6):441-9. Review.

Sabharwal NK, Stoykova B, Taneja AK, Lahiri A. “A randomized trial of exercise treadmill ECG versus stress SPECT myocardial perfusion imaging as an initial diagnostic strategy in stable patients with chest pain and suspected CAD: cost analysis.” *J Nucl Cardiol.* 2007 Apr;14(2):174-86. Erratum in: J Nucl Cardiol. 2007

Sampson UK, Dorbala S, Limaye A, Kwong R, Di Carli MF. “Diagnostic accuracy of rubidium-82 myocardial perfusion imaging with hybrid positron emission tomography/computed tomography in the detection of coronary artery disease.” *J Am Coll Cardiol.* 2007 Mar 13;49(10):1052-8. Epub 2007 Feb 26.

Graf S, Khorsand A, Gwechenberger M, Novotny C, Kletter K, Sochor H, Pirich C, Maurer G, Porenta G, Zehetgruber M. “Typical chest pain and normal coronary angiogram: cardiac risk factor analysis versus PET for detection of microvascular disease.” *J Nucl Med.* 2007 Feb;48(2):175-81.

Storto G, Sorrentino AR, Pellegrino T, Liuzzi R, Petretta M, Cuocolo A. “Assessment of coronary flow reserve by sestamibi imaging in patients with typical chest pain and normal coronary arteries.” *Eur J Nucl Med Mol Imaging*. 2007 Aug;34(8):1156-61. Epub 2007 Jan 6.

Shaw LJ, Marwick TH, Berman DS, Sawada S, Heller GV, Vasey C, Miller DD. “Incremental cost-effectiveness of exercise echocardiography vs. SPECT imaging for the evaluation of stable chest pain.” *Eur Heart J.* 2006 Oct;27(20):2448-58. Epub 2006 Sep 26.

Graf S, Khorsand A, Gwechenberger M, Schütz M, Kletter K, Sochor H, Dudczak R, Maurer G, Pirich C, Porenta G, Zehetgruber M. “Myocardial perfusion in patients with typical chest pain and normal angiogram.” *Eur J Clin Invest*. 2006 May;36(5):326-32.

Moralidis E, Anagnostopoulos C. “Cardiac radionuclide imaging in clinical decision making.” *Hell J Nucl Med.* 2005 May-Aug;8(2):95-102. Review.

Conti A, Sammicheli L, Gallini C, Costanzo EN, Antoniucci D, Barletta G.” Assessment of patients with low-risk chest pain in the emergency department: Head-to-head comparison of exercise stress echocardiography and exercise myocardial SPECT.” *Am Heart J*. 2005 May;149(5):894-901.

Ramakrishna G, Milavetz JJ, Zinsmeister AR, Farkouh ME, Evans RW, Allison TG, Smars PA, Gibbons RJ. “Effect of exercise treadmill testing and stress imaging on the triage of patients with chest pain: CHEER substudy.” *Mayo Clin Proc*. 2005 Mar;80(3):322-9.

Amsterdam EA, Lewis WR. “Stress imaging in chest pain units: is less more?” *Mayo Clin Proc.* 2005 Mar;80(3):317-9. No abstract available.

Bigi R, De Chiara B. “Prognostic value of noninvasive stressing modalities in patients with chest pain and normal coronary angiogram.” *Herz.* 2005 Feb;30(1):61-6. Review.

Weinsaft JW, Gade CL, Wong FJ, Kim HW, Min JK, Manoushagian SJ, Okin PM, Szulc M. “Diagnostic impact of SPECT image display on assessment of obstructive coronary artery disease.” *J Nucl Cardiol.* 2007 Sep-Oct;14(5):659-68.

Gould KL. “Positron emission tomography in coronary artery disease.” *Curr Opin Cardiol.* 2007 Sep;22(5):422-8. Review.

Toriyama T, Takase H, Goto T, Sugiura T, Nakazawa A, Hayashi K, Ishikawa H, Hikita Y, Ueda R, Dohi Y. “Coronary artery disease investigated using 99mTc-tetrofosmin myocardial SPECT.” *Eur J Clin Invest.* 2007 Jun;37(6):478-82.

Sabharwal NK, Stoykova B, Taneja AK, Lahiri A. “A randomized trial of exercise treadmill ECG versus stress SPECT myocardial perfusion imaging as an initial diagnostic strategy in stable patients with chest pain and suspected CAD: cost analysis.” *J Nucl Cardiol.* 2007 Apr;14(2):174-86. Erratum in: *J Nucl Cardiol.* 2007

Yoshinaga K, Chow BJ, Williams K, Chen L, deKemp RA, Garrard L, Lok-Tin Szeto
A, Aung M, Davies RA, Ruddy TD, Beanlands RS. “What is the prognostic value of myocardial perfusion imaging using rubidium-82 positron emission tomography?” *J Am Coll Cardiol.* 2006 Sep 5;48(5):1029-39. Epub 2006 Aug 17.

Di Carli MF, Dorbala S, Hachamovitch R. “Integrated cardiac PET-CT for the diagnosis and management of CAD.” *J Nucl Cardiol.* 2006 Mar-Apr;13(2):139-44. Review. No abstract available.

Bateman TM, Heller GV, McGhie AI, Friedman JD, Case JA, Bryngelson JR, Hertenstein GK, Moutray KL, Reid K, Cullom SJ. “Diagnostic accuracy of rest/stress ECG-gated Rb-82 myocardial perfusion PET: comparison with ECG-gated Tc-99m sestamibi SPECT.” *J Nucl Cardiol.* 2006 Jan-Feb;13(1):24-33.

Di Carli MF, Hachamovitch R. “Should PET replace SPECT for evaluating CAD? The end of the beginning.” *J Nucl Cardiol.* 2006 Jan-Feb;13(1):2-7. No abstract available.

Sdringola S, Loghin C, Boccalandro F, Gould KL. “Mechanisms of progression and regression of coronary artery disease by PET related to treatment intensity and clinical events at long-term follow-up.” *J Nucl Med.* 2006 Jan;47(1):59-67.

Conti A, Sammicheli L, Gallini C, Costanzo EN, Antoniucci D, Barletta G. “Assessment of patients with low-risk chest pain in the emergency department: Head-to-head comparison of exercise stress echocardiography and exercise myocardial SPECT.” *Am Heart J.* 2005 May;149(5):894-901.

Schinkel AF, Elhendy A, Biagini E, van Domburg RT, Valkema R, Rizello V, Pedone C, Simoons M, Bax JJ, Poldermans D. “Prognostic stratification using dobutamine stress 99mTc-tetrofosmin myocardial perfusion SPECT in elderly patients unable to perform exercise testing.” *J Nucl Med*. 2005 Jan;46(1):12-8.

Kontos MC, Tatum JL. “Imaging in the evaluation of the patient with suspected acute coronary syndrome.” *Cardiol Clin.* 2005 Nov;23(4):517-30, vii. Review.

Rao S, Lele V, Lele RD. “Prognostic value of 99mTc-Sestamibi stress Myocardial Perfusion Single Photon Emission Computed Tomography (SPECT) in ischemic heart disease.” *J Assoc Physicians India*. 2005 Dec;53:1036-42.

Beanlands RS, Chow BJ, Dick A, Friedrich MG, Gulenchyn KY, Kiess M, Leong-Poi H, Miller RM, Nichol G, Freeman M, Bogaty P, Honos G, Hudon G, Wisenberg G, Van Berkom J, Williams K, Yoshinaga K, Graham J; Canadian Cardiovascular Society; Canadian Association of Radiologists; Canadian Association of Nuclear Medicine; Canadian Nuclear Cardiology Society; Canadian Society of Cardiac Magnetic Resonance. “CCS/CAR/CANM/CNCS/CanSCMR joint position statement on advanced noninvasive cardiac imaging using positron emission tomography, magnetic resonance imaging and multidetector computed tomographic angiography in the diagnosis and evaluation of ischemic heart disease--executive summary.” *Can J Cardiol*. 2007 Feb;23(2):107-19.

Schinkel A, Bax J, Elhendy A, van Domburg R, Valkema R, Vourvouri E, et al. Long-term prognostic value of dobutamine stress echocardiography compared with myocardial perfusion scanning in patients unable to perform exercise tests. Am J Med 2004;117:1-9.

Olmos L, Dakik H, Gordon R, Dunn J, Verani M, Quinones M, et al. Long-term prognostic value of exercise echocardiography compared with exercise 201TI, ECG, and clinical variables in patients evaluated for coronary artery disease. Circulation 1998;98:2679-2686.

Gould KL, Goldstein RA, Mullani NA. “Economic analysis of clinical positron emission tomography of the heart with rubidium-82.” *J Nucl Med.* 1989 May;30(5):707-17.

Gould KL. “Clinical cardiac positron emission tomography: state of the art. *Circulation.* 1991 Sep;84(3 Suppl):I22-36. Review.

Mullani NA, Caras D, Ahn C, Lundberg G, Page D, Kleinman D, Bladuell N, Weisman E, Patillo M, Posthauer J, Simone G. “Fewer women than men have positive SPECT and PET cardiac findings among patients with no history of heart disease.” *J Nucl Med*. 2000 Feb;41(2):263-8.

Lucignani G, Landoni C, Paolini G, Messa MC, Gilardi MC, Rossetti C, Fazio F. “Positron emission tomography for the assessment of myocardial viability: a synopsis of methods and indications.” *Rays.* 1999 Jan-Mar;24(1):81-95. English, Italian.

Hör G, Kranert WT, Maul FD, Schröder O, Karimian-Tatriz A, Geb O, Baum RP,Scherer UW. “Gated metabolic positron emission tomography (GAPET) of the myocardium: 18F-FDG-PET to optimize recognition of myocardial hibernation.” *Nucl Med Commun.* 1998 Jun;19(6):535-45.

Yonekura Y, Tamaki N, Senda M, Nohara R, Kambara H, Konishi Y, Koide H, Kureshi SA, Saji H, Ban T, et al. “Detection of coronary artery disease with 13N-ammonia and high-resolution positron-emission computed tomography.” *Am Heart J*. 1987 Mar;113(3):645-54.

MacIntyre WJ, Go RT, King JL, Cook SA, Neumann DR, Saha GB, Antar MA. “Clinical outcome of cardiac patients with negative thallium-201 SPECT and positive rubidium-82 PET myocardial perfusion imaging.” *J Nucl Med.* 1993 Mar;34(3):400-4.

Simone GL, Mullani NA, Page DA, Anderson BA Sr. “Utilization statistics and diagnostic accuracy of a nonhospital-based positron emission tomography center for the detection of coronary artery disease using rubidium-82.” *Am J Physiol Imaging*. 1992 Jul-Dec;7(3-4):203-9.

Jadvar H, Strauss HW, Segall GM. “SPECT and PET in the evaluation of coronary artery disease.” *Radiographics.* 1999 Jul-Aug;19(4):915-26. Review.

Barnett K, Feldman JA. Noninvasive imaging techniques to aid in the triage of patients with suspected acute coronary syndrome: a review. Emerg Med Clin North Am. 2005 Nov;23(4):977-98. Review.

Vashist A, Abbott BG. Noninvasive cardiac imaging in the evaluation of suspected acute coronary syndromes. Expert Rev Cardiovasc Ther. 2005 May;3(3):473-86. Review.

Bülow H, Schwaiger M. Nuclear cardiology in acute coronary syndromes. Q J Nucl Med Mol Imaging. 2005 Mar;49(1):59-71. Review.

Kontos MC, Tatum JL. Imaging in the evaluation of the patient with suspected acute coronary syndrome. Semin Nucl Med. 2003 Oct;33(4):246-58. Review.

Abbott BG, Jain D. Impact of myocardial perfusion imaging on clinical management and the utilization of hospital resources in suspected acute coronary syndromes. Nucl Med Commun. 2003 Oct;24(10):1061-9.

Conti A, Zanobetti M, Grifoni S, Berni G, Costanzo E, Gallini C, Ferri P, Pieroni C. Implementation of myocardial perfusion imaging in the early triage of

patients with suspected acute coronary syndromes. Nucl Med Commun. 2003 Oct;24(10):1055-60.

Anand DV, Lahiri A. Myocardial perfusion imaging versus biochemical markers in acute coronary syndromes. Nucl Med Commun. 2003 Oct;24(10):1049-54.

Abbott BG, Wackers FJ. Use of radionuclide imaging in acute coronary syndromes. Curr Cardiol Rep. 2003 Jan;5(1):25-31. Review.

Abbott BG, Jain D. Nuclear cardiology in the evaluation of acute chest pain in the emergency department. Echocardiography. 2000 Aug;17(6 Pt 1):597-604. Review.

Kobayashi H. Myocardial perfusion imagings in acute coronary syndromes. Nippon Rinsho. 1998 Oct;56(10):2539-43. Review. Japanese.

Kim SC, Adams SL, Hendel RC. Role of nuclear cardiology in the evaluation of acute coronary syndromes. Ann Emerg Med. 1997 Aug;30(2):210-8. Review.

Gibbons RJ, Balady GJ, Beasley JW, et al. ACC/AHA Guidelines for Exercise Testing: a report of the American College of Cardiology/American Heart Association Task Force on practice Guidelines (Committee on Exercise Testing). J Am Coll Cardiol 1997;30:260-311.

DeLorenzo A, Hachamovitch R, Kang X, et al. Prognostic value of myocardial perfusion SPECT versus exercise electrocardiography in patients with ST-segment depression on resting electrocardiography. J Nucl Cardiol 2005;12:655-61.

De Winter O, Velghe A, Van de Veire N, et al. Incremental prognostic value of combined perfusion and function assessment during myocardial gated SPECT in patients aged 75 years or older. J Nucl Cardiol 2005;12:662-70.

Schinkel AF, Elhendy A, Biagini E, et al. Prognostic stratification using dobutamine stress 99mTc-tetrofosmin myocardial perfusion SPECT in elderly patients unable to perform exercise testing. J Nucl Med 2005;46:12-8.

Pedone C, Schinkel AF, Elhendy A, et al. Incremental prognostic value of dobutamine-atropine stress 99mTc-tetrofosmin myocardial perfusion imaging for predicting outcome in diabetic patients with limited exercise capacity. Eur J Nucl Med Mol Imaging 2005;32:1057-63.

Fleischmann KE, Humink MG, Kuntz KM, et al. Exercise echocardiography or exercise SPECT imaging? A meta-analysis of diagnostic test performance. JAMA 1998;280:913-20.

Mowatt G, Brazzelli M, Gemmell H, et al. Aberdeen Technology Assessment Group. Systematic review of the prognostic effectiveness of SPECT myocardial perfusion scintigraphy in patient with suspected or known coronary artery disease and following myocardial infarction. Nucl Med Comm 2005;26:217-29.

Giri S, Shaw LJ, Murthy D, et al. Impact of diabetes on the risk stratification using stress single-photon emission computed tomography myocardial perfusion imaging in patients with symptoms suggestive of coronary artery disease. Circulation 2002;105:32-40.

Shaw LJ, Hachamovitch R, Berman DS, et al. The economic consequences of available diagnostic and prognostic strategies for the evaluation of stable angina patients: an observational assessment of the value of precatheterization ischemia. Economics of Noninvasive Diagnosis (END) Multicenter Study Group. J Am Coll Cardiol 1999;33:661-9.

Des Prez RD, Shaw LJ, Gillespie RL, et al. Cost-effectiveness of myocardial perfusion imaging: a summary of the currently available literature. J Nucl Cardiol 2005;12:750-9.

II. References from 2005 SPECT MPI Appropriateness Criteria:

Morise AP, Haddad WJ, Beckner D. “Development and validation of a clinical score to estimate the probability of coronary artery disease in men and women presenting with suspected coronary disease.” *Am J Med* 1997;102:350–6.

Pryor DB, Harrell FE Jr., Lee KL, Califf RM, Rosati RA. “Estimating the likelihood of significant coronary artery disease.” *Am J Med* 1983;75:771– 80.

Diamond GA, Forrester JS. “Analysis of probability as an aid in the clinical diagnosis of coronary-artery disease.” *N Engl J Med* 1979;300: 1350–8.

Table 2. Detection of CAD/Risk Assessment Without Chest Pain Syndrome

	Indication	**Appropriate Use Criteria (Median Score)**
	Asymptomatic	
12	• Low CHD risk (ATP III risk criteria)	
13	• Moderate CHD risk (ATP III risk criteria) • ECG interpretable	

14	• Moderate CHD risk (ATP III risk criteria) • ECG uninterpretable	
15	• High CHD risk (ATP III risk criteria)	
	New-Onset or Newly Diagnosed Heart Failure with LV Systolic Dysfunction Without Ischemic Equivalent	
16	• No prior CAD evaluation AND no planned coronary angiography	
	New-onset Atrial Fibrillation	
17	• Part of evaluation when etiology unclear	
	Ventricular Tachycardia	
18	• Low CHD risk (ATP III risk criteria)	
19	• Moderate or High CHD risk (ATP III risk criteria)	
	Syncope	
20	• Low CHD risk (ATP III risk criteria)	
21	• Moderate or high CHD risk (ATP III risk criteria)	
	Elevated Troponin	
22	• Troponin elevation without additional evidence of acute coronary syndrome	

I. New Lit Search:

Bax JJ, van der Wall EE. "Assessment of coronary artery disease in patients with (a)symptomatic diabetes." *Eur Heart J*. 2006 Mar;27(6):631-2. Epub 2006 Feb 23. No abstract available.

Askew JW, Miller TD, Hodge DO, Gibbons RJ. "The value of myocardial perfusion single-photon emission computed tomography in screening asymptomatic patients with atrial fibrillation for coronary artery disease. *J Am Coll Cardiol*. 2007 Sep 11;50(11):1080-5. Epub 2007 Aug 24.

Haji SA. "Dyspnea and stress testing." *N Engl J Med*. 2006 Feb 23;354(8):871-3; author reply 871-3. No abstract available.

Abidov A, Rozanski A, Hachamovitch R, Hayes SW, Aboul-Enein F, Cohen I, Friedman JD, Germano G, Berman DS. "Prognostic significance of dyspnea in patients referred for cardiac stress testing." *N Engl J Med.* 2005 Nov 3;353(18):1889-98.

Bax JJ, Bonow RO, Tschöpe D, Inzucchi SE, Barrett E; "Global Dialogue Group for the Evaluation of Cardiovascular Risk in Patients With Diabetes. The potential of myocardial perfusion scintigraphy for risk stratification of asymptomatic patients with type 2 diabetes." *J Am Coll Cardiol.* 2006 Aug 15;48(4):754-60. Epub 2006 Jul 24.

Freeman M. "Myocardial perfusion imaging in diabetes mellitus." *Can J Cardiol.* 2006 Feb;22 Suppl A:22A-25A. Review.

Lacourcière Y, Côté C, Lefebvre J, Dumont M. “Noninvasive detection of silent coronary artery disease in patients with essential hypertension, alone or associated with type 2 diabetes mellitus, using dipyridamole stress 99mtechnetium-sestamibi myocardial perfusion imaging.” *Can J Cardiol*. 2006 Feb;22 Suppl A:16A-21A.

Mieres JH, Shaw LJ, Arai A, Budoff MJ, Flamm SD, Hundley WG, Marwick TH, Mosca L, Patel AR, Quinones MA, Redberg RF, Taubert KA, Taylor AJ, Thomas GS, Wenger NK; Cardiac Imaging Committee, Council on Clinical Cardiology, and the Cardiovascular Imaging and Intervention Committee, Council on Cardiovascular Radiology and Intervention, American Heart Association. “Role of noninvasive testing in the clinical evaluation of women with suspected coronary artery disease: Consensus statement from the Cardiac Imaging Committee, Council on Clinical Cardiology, and the Cardiovascular Imaging and Intervention Committee, Council on Cardiovascular Radiology and Intervention, American Heart Association.” *Circulation.* 2005 Feb 8;111(5):682-96. Epub 2005 Feb 1.

Balaravi B, Miller TD, Hodge DO, Gibbons RJ. “The value of stress single photon emission computed tomography in patients without known coronary artery disease presenting with dyspnea.” *Am Heart J.* 2006 Sep;152(3):551-7.

Naidoo VV. “Review of gated SPECT imaging in women with suspected coronary heart disease*.” J Nucl Cardiol*. 2006 Jul;13(4):474-9. Review. No abstract available.

Freeman M. “Myocardial perfusion imaging in diabetes mellitus.” *Can J Cardiol.* 2006 Feb;22 Suppl A:22A-25A. Review.

Elhendy A, Schinkel AF, van Domburg RT, Bax JJ, Valkema R, Huurman A, Feringa HH, Poldermans D. “Risk stratification of patients with angina pectoris by stress 99mTc-tetrofosmin myocardial perfusion imaging.” *J Nucl Med.* 2005 Dec;46(12):2003-8.

Valeti US, Miller TD, Hodge DO, Gibbons RJ. “Exercise single-photon emission computed tomography provides effective risk stratification of elderly men and elderly women.” *Circulation.* 2005 Apr 12;111(14):1771-6. Epub 2005 Apr 4.

Wackers FJ. “Diabetes and coronary artery disease: the role of stress myocardial perfusion imaging.” *Cleve Clin J Med.* 2005 Jan;72(1):21-5, 29-33. Review.

Sdringola S, Patel D, Gould KL. “High prevalence of myocardial perfusion abnormalities on positron emission tomography in asymptomatic persons with a

parent or sibling with coronary artery disease." *Circulation.* 2001 Jan 30;103(4):496-501.

Dayanikli F, Grambow D, Muzik O, Mosca L, Rubenfire M, Schwaiger M. "Early detection of abnormal coronary flow reserve in asymptomatic men at high risk for coronary artery disease using positron emission tomography." *Circulation.* 1994 Aug;90(2):808-17.

Arrighi JA, Ng CK, Dey HM, Wackers FJ, Soufer R. "Effect of left ventricular function on the assessment of myocardial viability by technectium-99m sestamibi and correlation with positron emission tomography in patients with healed myocardial infarcts or stable angina pectoris, or both." *Am J Cardiol*. 1997 Oct 15;80(8):1007-13.

Schinkel AF, Elhendy A, Biagini E, et al. Prognostic stratification using dobutamine stress 99mTc-tetrofosmin myocardial perfusion SPECT in elderly patients unable to perform exercise testing. J Nucl Med 2005;46:12-8.

Pedone C, Schinkel AF, Elhendy A, et al. Incremental prognostic value of dobutamine-atropine stress 99mTc-tetrofosmin myocardial perfusion imaging for predicting outcome in diabetic patients with limited exercise capacity. Eur J Nucl Med Mol Imaging 2005;32:1057-63.

Fleischmann KE, Humink MG, Kuntz KM, et al. Exercise echocardiography or exercise SPECT imaging? A meta-analysis of diagnostic test performance. JAMA 1998;280:913-20.

Mowatt G, Brazzelli M, Gemmell H, et al. Aberdeen Technology Assessment Group. Systematic review of the prognostic effectiveness of SPECT myocardial perfusion scintigraphy in patient with suspected or known coronary artery disease and following myocardial infarction. Nucl Med Comm 2005;26:217-29.

Fuster V, Ryden LE, Cannom DS, et al. ACC/AHA/ESC 2006 guidelines for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association task force on practice guidelines and the European Society of Cardiology Committee for practice guidelines. (Writing Committee to Revise the 2001 Guidelines for the Management of Patients with Atrial Fibrillation). J Am Coll Cardiol 2006;48:e149-246.

Fleg JL, Gerstenblith G, Zonderman A, et al. Prevalence and prognostic significance of exercise-induced silent myocardial ischemia detected by thallium scintigraphy and electrocardiography in asymptomatic volunteers. Circulation 1990;81:428-36.

Danias PG, Papaioannou GI, Ahlberg AW, et al. Usefulness of electrocardiographic-gated stress technetium-99m sestamibi singlephoton emission computed tomography to differentiate ischemic from nonischemic cardiomyopathy. Am J Cardiol 2004;94:14-9.

Danias PG, Ahlberg AW, Clark BA III, et al. Combined assessment of myocardial perfusion and left ventricular function with exercise technetium-99m sestamibi gated single-photon emission computed tomography can differentiate between ischemic and nonischemic dilated cardiomyopathy. Am J Cardiol 1998;82:1253-8.

I. References from 2005 SPECT Appropriateness Criteria:

Grundy SM, Pasternak R, Greenland P, Smith S Jr., Fuster V. "AHA/ACC scientific statement: assessment of cardiovascular risk by use of multiple-risk-factor assessment equations: a statement for healthcare professionals from the American Heart Association and the American College of Cardiology." *J Am Coll Cardiol* 1999;34:1348–59.

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

	Indication	Appropriate Use Criteria (Median Score)
	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	
24	• Intermediate to High CHD risk (ATP III risk criteria) • Last stress imaging study done less than 2 years ago	
25	• Low CHD risk (ATP III risk criteria) • Last stress imaging study done more than 2 years ago	
26	• Intermediate to High CHD risk (ATP III risk criteria) • Last stress imaging study done more than 2 years ago	
	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	
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	
	Prior non-invasive evaluation	

29	• Equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern	
	New or Worsening Symptoms	
30	• Abnormal coronary angiography OR abnormal prior stress imaging study	
31	• Normal coronary angiography OR normal prior stress imaging study	
	Coronary Angiography (Invasive or Noninvasive)	
32	• Coronary stenosis or anatomic abnormality of uncertain significance.	
	Asymptomatic **Prior Coronary Calcium Agatston Score**	
33	• Agatston score less than 100	
34	• Low to Intermediate CHD risk • Agatston score between 100-400	
35	• High CHD risk • Agatston score between 100-400	
36	• Agatston score greater than 400	
	Duke Treadmill Score	
37	• Low-Risk Duke treadmill score	
38	• Intermediate-Risk Duke treadmill score	
39	• High-Risk Duke treadmill score	

I. New Lit Search:

Berman DS, Shaw LJ, Hachamovitch R, Friedman JD, Polk DM, Hayes SW, Thomson LE, Germano G, Wong ND, Kang X, Rozanski A. "Comparative use of radionuclide stress testing, coronary artery calcium scanning, and noninvasive coronary angiography for diagnostic and prognostic cardiac assessment." *Semin Nucl Med*. 2007 Jan;37(1):2-16. Review.

Ramakrishna G, Miller TD, Breen JF, Araoz PA, Hodge DO, Gibbons RJ. "Relationship and prognostic value of coronary artery calcification by electron beam computed tomography to stress-induced ischemia by single photon emission computed tomography. *Am Heart J* 2007; 153:807-14.

Koehli M, Monbaron D, Prior JO, Calcagni ML, Fivaz-Arbane M, Stauffer JC, Gaillard RC, Bischof Delaloye A, Ruiz J. "SPECT myocardial perfusion imaging: long-term prognostic value in diabetic patients with and without coronary artery disease." *Nuklearmedizin*. 2006;45(2):74-81.

Baghdasarian SB, Heller GV. “The role of myocardial perfusion imaging in the diagnosis of patients with coronary artery disease: developments over the past year.” *Curr Opin Cardiol*. 2005 Sep;20(5):369-74. Review.

Nagao T, Chikamori T, Hida S, Igarashi Y, Kuwabara Y, Nishimura S, Yamazaki J, Yamashina A; Q-PROVE Study Group. “Quantitative gated single-photon emission computed tomography with (99m)Tc sestamibi predicts major cardiac events in elderly patients with known or suspected coronary artery disease: the QGS-Prognostic Value in the Elderly” *(Q-PROVE) Study. Circ J.* 2007 Jul;71(7):1029-34.

Vashist A, Abbott BG. “Noninvasive cardiac imaging in the evaluation of suspected acute coronary syndromes.” *Expert Rev Cardiovasc Ther*. 2005 May;3(3):473-86. Review.

Bülow H, Schwaiger M. “Nuclear cardiology in acute coronary syndromes.” *Q J Nucl Med Mol Imaging.* 2005 Mar;49(1):59-71. Review.

Becker A, Leber A, Becker C, Knez A. “Predictive value of coronary calcifications for future cardiac events in asymptomatic individuals.” *Am Heart J*. 2008 Jan;155(1):154-60. Epub 2007 Oct 17.

Berman DS, Hachamovitch R, Shaw LJ, Friedman JD, Hayes SW, Thomson LE, Fieno DS, Germano G, Wong ND, Kang X, Rozanski A. “Roles of nuclear cardiology, cardiac computed tomography, and cardiac magnetic resonance: Noninvasive risk stratification and a conceptual framework for the selection of noninvasive imaging tests in patients with known or suspected coronary artery disease.” *J Nucl Med.* 2006 Jul;47(7):1107-18. Review.

Bax JJ, Schuifj JD. “Can Coronary Calcification Define the Warranty Period of a Normal Myocardial Perfusion Study?” *Mayo Clinic Proceedings*. 2008 Jan; 83(1): 10-12. Editorial.

Baghdasarian SB, Heller GV. “The role of myocardial perfusion imaging in the diagnosis of patients with coronary artery disease: developments over the past year.” *Curr Opin Cardiol.* 2005 Sep;20(5):369-74. Review.

Ahlberg AW, Baghdasarian SB, Athar H, Thompsen JP, Katten DM, Noble GL, Mamkin I, Shah AR, Leka IA, Heller GV. “Symptom-limited exercise combined with dipyridamole stress: prognostic value in assessment of known or suspected coronary artery disease by use of gated SPECT imaging.” *J Nucl Cardiol.* 2008 Jan-Feb;15(1):42-56.

Askew JW, Miller TD, Araoz PA, Breen JF, Hodge DO, Gibbons RJ. “Abnormal electron beam computed tomography results: the value of repeating myocardial perfusion single-photon emission computed tomography in the

ongoing assessment of coronary artery disease." *Mayo Clin Proc*. 2008 Jan;83(1):17-22.

Becker A, Leber A, Becker C, Knez A. "Predictive value of coronary calcifications for future cardiac events in asymptomatic individuals." *Am Heart J.* 2008 Jan;155(1):154-60. Epub 2007 Oct 17.

Schepis T, Gaemperli O, Koepfli P, Namdar M, Valenta I, Scheffel H, Leschka S, Husmann L, Eberli FR, Luscher TF, Alkadhi H, Kaufmann PA. "Added value of coronary artery calcium score as an adjunct to gated SPECT for the evaluation of coronary artery disease in an intermediate-risk population." *J Nucl Med*. 2007 Sep;48(9):1424-30.

Rosman J, Shapiro M, Pandey A, VanTosh A, Bergmann SR. "Lack of correlation between coronary artery calcium and myocardial perfusion imaging." *J Nucl Cardiol*. 2006 May-Jun;13(3):333-7.

Yang MF, Dou KF, Liu XJ, Yang YJ, He ZX. "Prognostic value of normal exercise 99mTc-sestamibi myocardial tomography in patients with angiographic coronary artery disease." *Nucl Med Commun*. 2006 Apr;27(4):333-8.

Gudmundsson P, Winter R, Dencker M, Kitlinski M, Thorsson O, Ljunggren L, Willenheimer R. "Real-time perfusion adenosine stress echocardiography versus myocardial perfusion adenosine scintigraphy for the detection of myocardial ischaemia in patients with stable coronary artery disease." *Clin Physiol Funct Imaging.* 2006 Jan;26(1):32-8.

Mowatt G, Brazzelli M, Gemmell H, Hillis GS, Metcalfe M, Vale L; Aberdeen Technology Assessment Review Group. "Systematic review of the prognostic effectiveness of SPECT myocardial perfusion scintigraphy in patients with suspected or known coronary artery disease and following myocardial infarction." *Nucl Med Commun*. 2005 Mar;26(3):217-29.

Ahlberg AW, Baghdasarian SB, Athar H, Thompsen JP, Katten DM, Noble GL, Mamkin I, Shah AR, Leka IA, Heller GV. "Symptom-limited exercise combined with dipyridamole stress: prognostic value in assessment of known or suspected coronary artery disease by use of gated SPECT imaging." *J Nucl Cardiol.* 2008 Jan-Feb;15(1):42-56.

Berman DS, Kang X, Slomka PJ, Gerlach J, de Yang L, Hayes SW, Friedman JD, Thomson LE, Germano G. "Underestimation of extent of ischemia by gated SPECT myocardial perfusion imaging in patients with left main coronary artery disease." *J Nucl Cardiol.* 2007 Jul;14(4):521-8.

Parkash R, deKemp RA, Ruddy TD, Kitsikis A, Hart R, Beauchesne L, Williams K, Davies RA, Labinaz M, Beanlands RS. "Potential utility of rubidium

82 PET quantification in patients with 3-vessel coronary artery disease." *J Nucl Cardiol*. 2004 Jul-Aug;11(4):440-9. Erratum in: *J Nucl Cardiol*. 2004 Nov-Dec;11(6):756. Beauschene, L [corrected to Beauchesne, L].

Muzik O, Duvernoy C, Beanlands RS, Sawada S, Dayanikli F, Wolfe ER Jr, Schwaiger M. "Assessment of diagnostic performance of quantitative flow measurements in normal subjects and patients with angiographically documented coronary artery disease by means of nitrogen-13 ammonia and positron emission tomography." *J Am Coll Cardiol.* 1998 Mar 1;31(3):534-40.

Araujo LI, Lammertsma AA, Rhodes CG, McFalls EO, Iida H, Rechavia E, Galassi A, De Silva R, Jones T, Maseri A. "Noninvasive quantification of regional myocardial blood flow in coronary artery disease with oxygen-15-labeled carbon dioxide inhalation and positron emission tomography." *Circulation.* 1991 Mar;83(3):875-85.

Wijns W, Camici PG. "The value of quantitative myocardial perfusion imaging with positron emission tomography in coronary artery disease." *Herz.* 1997 Apr;22(2):87-95. Review.

Haas F, Augustin N, Holper K, Wottke M, Haehnel C, Nekolla S, Meisner H, Lange R, Schwaiger M. "Time course and extent of improvement of dysfunctioning myocardium in patients with coronary artery disease and severely depressed left ventricular function after revascularization: correlation with positron emission tomographic findings." *J Am Coll Cardiol.* 2000 Nov 15;36(6):1927-34.

Di Carli MF, Davidson M, Little R, Khanna S, Mody FV, Brunken RC, Czernin J, Rokhsar S, Stevenson LW, Laks H, et al. "Value of metabolic imaging with positron emission tomography for evaluating prognosis in patients with coronary artery disease and left ventricular dysfunction." *Am J Cardiol.* 1994 Mar 15;73(8):527-33.

Amanullah AM. Diagnostic and prognostic value of myocardial perfusion imaging in patients with known or suspected stable coronary artery disease. Echocardiography. 2000 Aug;17(6 Pt 1):587-95. Review.

Verani MS. Stress myocardial perfusion imaging versus echocardiography for the diagnosis and risk stratification of patients with known or suspected coronary artery disease. Semin Nucl Med. 1999 Oct;29(4):319-29. Review.

Giri S, Shaw LJ, Murthy D, et al. Impact of diabetes on the risk stratification using stress single-photon emission computed tomography myocardial perfusion imaging in patients with symptoms suggestive of coronary artery disease. Circulation 2002;105:32-40.

Hachamovitch R, Berman DS, Shaw LJ, et al. Incremental prognostic value of myocardial perfusion single photon emission computed tomography for the prediction of cardiac death: differential stratification for risk of cardiac death and myocardial infarction. Circulation 1998;97:535-43.

Metz LD, Beattie M, Hom R, et al. The prognostic value of normal myocardial perfusion imaging and exercise echocardiography. J Am Coll Cardiol 2007;49:227-37.

Iskander S, Iskandrian AE. Risk assessment using single-photon emission computed tomographic technetium-99m sestamibi imaging. J Am Coll Cardiol 1998;32:57-62.

Schinkel AF, Elhendy A, Van Domburg RT, et al. Long-term prognostic value of dobutamine stress 99mTc-sestamibi SPECT: single-center experience with 8-year follow-up. Radiology 2002;225:701-6.

Bax JJ, Inzucchi SE, Bonow RO, et al. Cardiac imaging for risk stratification in diabetes. Diabetes Care 2007;30:1295-304.

Hachamovitch R, Hayes S, Friedman JD, et al. Determinants of risk and its temporal variation in patients with normal stress myocardial perfusion scans: what is the warranty period of a normal scan? J Am Coll Cardiol 2003;41:1329-40.

Hachamovitch R, Berman DS, Kiat H, et al. Exercise myocardial perfusion SPECT in patients without known coronary artery disease: incremental prognostic value and use in risk stratification. Circulation 1996;93:905-14.

Garcia MJ, Lessick J, Hoffmann MH. Accuracy of 16-row multidetector computed tomography for the assessment of coronary artery stenosis. JAMA 2006;296:403-11.

Di Carli MF, Hachamovitch R. New technology for noninvasive evaluation of coronary artery disease. Circulation 2007;115:1464-80.

Schuijf JD, Wijns W, Wouter Jukema J, et al. Relationship between noninvasive coronary angiography with multi-slice computed tomography and myocardial perfusion imaging. J Am Coll Cardiol 2006;48:2508-14.

Hacker M, Jakobs T, Matthiesen F, et al. Comparison of spiral multi-detector CT angiography and myocardial perfusion imaging in the noninvasive detection of functionally relevant coronary artery lesions: first clinical experiences. J Nucl Med 2005;46:1294-300.

Table 4. Risk Assessment: Preoperative Evaluation for Non-Cardiac Surgery

	Indication	Appropriate Use Criteria (Median Score)
	Low-Risk Surgery	
40	• Preoperative evaluation for non-cardiac surgery risk assessment	
	Intermediate-Risk Surgery	
41	• Moderate to Good functional capacity (greater than or equal to 4 METs)	
42	• No clinical risk factors†	
43	• Greater than or equal to 1 clinical risk factor • Poor or unknown functional capacity (less than 4 METs)	
44	• Asymptomatic up to 1 year post normal catheterization, non-invasive test, or previous revascularization	
	Vascular Surgery	
45	• Moderate to Good functional capacity (greater than or equal to 4 METs)	
46	• No clinical risk factors†	
47	• Greater than or equal to 1 clinical risk factor • Poor or unknown functional capacity (less than 4 METs)	
48	• Asymptomatic up to 1 year post normal catheterization, non-invasive test, or previous revascularization	

I. New Lit Search:

Watanabe K, Ohsumi Y, Abe H, Hattori M, Minatoguchi S, Fujiwara H. "Benefits of quantitative gated SPECT in evaluation of perioperative cardiac risk in noncardiac surgery." *Ann Nucl Med*. 2007 Dec;21(10):563-8. Epub 2007 Dec 25.

Haas F, Haehnel CJ, Picker W, Nekolla S, Martinoff S, Meisner H, Schwaiger M. "Preoperative positron emission tomographic viability assessment and perioperative and postoperative risk in patients with advanced ischemic heart disease." *J Am Coll Cardiol.* 1997 Dec;30(7):1693-700.

Lucignani G, Paolini G, Landoni C, Zuccari M, Paganelli G, Galli L, Di Credico G, Vanoli G, Rossetti C, Mariani MA, et al. "Presurgical identification of hibernating myocardium by combined use of technetium-99m hexakis 2-methoxyisobutylisonitrile single photon emission tomography and fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography in patients with coronary artery disease."
Eur J Nucl Med. 1992;19(10):874-81.

Kertai M, Boersma E, Bax J. A meta-analysis comparing the prognostic accuracy of six diagnostic rests for predicting perioperative cardiac risk in patients undergoing major vascular surgery. Heart 2003;89:1327-34.

Hachamovitch R, Berman DS, Shaw LJ, et al. Incremental prognostic value of myocardial perfusion single photon emission computed tomography for the prediction of cardiac death: differential stratification for risk of cardiac death and myocardial infarction. Circulation 1998;97:535-43.

Iskander S, Iskandrian AE. Risk assessment using single-photon emission computed tomographic technetium-99m sestamibi imaging. J Am Coll Cardiol 1998;32:57-62.

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

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

I. New Lit Search:

Kontos MC, Tatum JL. “Imaging in the evaluation of the patient with suspected acute coronary syndrome.” *Cardiol Clin.* 2005 Nov;23(4):517-30, vii. Review.

Marso SP, Miller T, Rutherford BD, Gibbons RJ, Qureshi M, Kalynych A, Turco M,Schultheiss HP, Mehran R, Krucoff MW, Lansky AJ, Stone GW. "Comparison of myocardial reperfusion in patients undergoing percutaneous coronary intervention in ST-segment elevation acute myocardial infarction with versus without diabetes mellitus (from the EMERALD Trial)." *Am J Cardiol*. 2007 Jul 15;100(2):206-10. Epub 2007 Jun 4.

De Lorenzo A, Hachamovitch R, Kang X, Gransar H, Sciammarella MG, Hayes SW, Friedman JD, Cohen I, Germano G, Berman DS. "Prognostic value of myocardial perfusion SPECT versus exercise electrocardiography in patients with ST-segment depression on resting electrocardiography." *J Nucl Cardiol.* 2005 Nov-Dec;12(6):655-61.

Bülow H, Schwaiger M. "Nuclear cardiology in acute coronary syndromes." *Q J Nucl Med Mol Imaging*. 2005 Mar;49(1):59-71. Review.

de Silva R, Yamamoto Y, Rhodes CG, Iida H, Nihoyannopoulos P, Davies GJ, Lammertsma AA, Jones T, Maseri A. "Preoperative prediction of the outcome of coronary revascularization using positron emission tomography." *Circulation.* 1992 Dec;86(6):1738-42.

Lee BC, Chen SY, Hsu HC, Su MY, Wu YW, Chien KL, Tseng WY, Chen MF, Lee YT. Effect of cardiac rehabilitation on myocardial perfusion reserve in postinfarction patients. Am J Cardiol. 2008 May 15;101(10):1395-402. Epub 2008 Mar 26.

Atwood E, Jensen D, Froelicher V, Gerber K, Witztum K, Slutsky R, Ashburn W. Radionuclide perfusion images before and after cardiac rehabilitation. Aviat Space Environ Med. 1980 Sep;51(9 Pt 1):892-8.

Table 6. Risk Assessment: Post-Revascularization (PCI or CABG)
I. New Lit Search:

	Indication	**Appropriate Use Criteria (Median Score)**
	Symptomatic	
55	• Evaluation of ischemic equivalent	
	Asymptomatic	
56	• Incomplete revascularization • Additional revascularization feasible	
57	• Less than 5 years after CABG	
58	• Greater than or equal to 5 years after CABG	
59	• Less than 2 years after PCI	

60	• Greater than or equal to 2 years after PCI	
	Cardiac Rehabilitation	
61	• Prior to initiation of cardiac rehabilitation (as a stand-alone indication)	

Slart RH, Bax JJ, van Veldhuisen DJ, van der Wall EE, Dierckx RA, de Boer J, Jager PL. "Prediction of functional recovery after revascularization in patients with coronary artery disease and left ventricular dysfunction by gated FDG-PET." *J Nucl Cardiol.* 2006 Mar-Apr;13(2):210-9.

Adams GL, Ambati SR, Adams JM, Borges-Neto S. "Role of nuclear imaging after coronary revascularization." *J Nucl Cardiol.* 2006 Mar-Apr;13(2):163-9. Review. No abstract available.

Acampa W, Evangelista L, Petretta M, Liuzzi R, Cuocolo A. "Usefulness of stress cardiac single-photon emission computed tomographic imaging late after percutaneous coronary intervention for assessing cardiac events and time to such events." *Am J Cardiol.* 2007 Aug 1;100(3):436-41. Epub 2007 Jun 13.

Wu YW, Tadamura E, Yamamuro M, Kanao S, Marui A, Tanabara K, Komeda M, Togashi K. "Comparison of contrast-enhanced MRI with (18)F-FDG PET/201Tl SPECT in dysfunctional myocardium: relation to early functional outcome after surgical revascularization in chronic ischemic heart disease." *J Nucl Med*. 2007 Jul;48(7):1096-103. Erratum in: J Nucl Med. 2007 Nov;48(11):1789.

Fenchel M, Franow A, Stauder NI, Kramer U, Helber U, Claussen CD, Miller S. "Myocardial perfusion after angioplasty in patients suspected of having single-vessel coronary artery disease: improvement detected at rest-stress first-pass perfusion MR imaging--initial experience." *Radiology.* 2005 Oct;237(1):67-74. Epub 2005 Aug 26.

Beanlands RS, Ruddy TD, deKemp RA, Iwanochko RM, Coates G, Freeman M, Nahmias C, Hendry P, Burns RJ, Lamy A, Mickleborough L, Kostuk W, Fallen E, Nichol G; PARR Investigators. "Positron emission tomography and recovery following revascularization (PARR-1): the importance of scar and the development of a prediction rule for the degree of recovery of left ventricular function." *J Am Coll Cardiol*. 2002 Nov 20;40(10):1735-43.

Adams GL, Ambati SR, Adams JM, Borges-Neto S. Role of nuclear imaging after coronary revascularization. J Nucl Cardiol 2006;13:163-9.

Zellweger MJ, Lewin HC, Lai S, et al. When to stress patients after coronary artery bypass surgery? Risk stratification in patients early and late post-

CABG using stress myocardial perfusion SPECT: implications of appropriate clinical strategies. J Am Coll Cardiol 2001;37:144-52.

Lauer MS, Lytle B, Pashkow F, Snader CE, Marwick TH. Prediction of death and myocardial infarction by screening with exercise-thallium testing after coronary-artery-bypass grafting. Lancet 1998;351:615-22.

Bergmann SR, Giedd KN. Silent ischemia: unsafe at any time. J Am Coll Cardiol 2003;42:41-4.

Cottin Y, Rezaizadeh K, Touzery C, et al. Long-term prognostic value of 201Tl single-photon emission computed tomographic myocardial perfusion imaging after coronary stenting. Am Heart J 2001;141:999-1006.

Zellweger MJ, Weinbacher M, Zutter AW, et al. Long-term outcome of patients with silent versus symptomatic ischemia six months after percutaneous coronary intervention and stenting. J Am Coll Cardiol 2003;42:33-40.

Pfisterer M, Rickenbacher P, Kiowski W, Müller-Brand J, Burkart F. Silent ischemia after percutaneous coronary angioplasty: incidence and prognostic significance. J Am Coll Cardiol 1993;22:1446-54.

Ruygrok PN, Webster MW, de Valk V, et al. Clinical and angiographic factors associated with asymptomatic restenosis after percutaneous coronary intervention. Circulation 2001;104:2289-94.

Hecht HS, Shaw RE, Chin HL, Ryan C, Stertzer SH, Myler RK. Silent ischemia after coronary angioplasty: evaluation of restenosis and extent of ischemia in asymptomatic patients by tomographic thallium-201 exercise imaging and comparison with symptomatic patients. J Am Coll Cardiol 1991;17:670-7.

Marie PY, Danchin N, Karcher G, et al. Usefulness of exercise SPECT-thallium to detect asymptomatic restenosis in patients who had angina before coronary angioplasty. Am Heart J 1993;126:571-7.

Table 7. Assessment of Viability/Ischemia

	Indication	Appropriate Use Criteria (Median Score)
	Ischemic Cardiomyopathy/Assessment of Viability	
62	• Known severe LV dysfunction • Patient eligible for revascularization	

I. New Lit Search:

Di Carli MF, Dorbala S, Curillova Z, Kwong RJ, Goldhaber SZ, Rybicki FJ,

Hachamovitch R.. “Relationship between CT coronary angiography and stress perfusion imaging in patients with suspected ischemic heart disease assessed by integrated PET-CT imaging.” *J Nucl Cardiol.* 2007 Nov-Dec;14(6):799-809. Epub 2007 Oct 22.

Banerjee SK, Haque KM, Sharma AK, Ahmed CM, Iqbal AT, Nisa L. “Role of exercise tolerance test (ETT) and gated single photon emission computed tomography-myocardial perfusion imaging (SPECT-MPI) in predicting severity of ischemia in patients with chest pain.” *Bangladesh Med Res Counc Bull*. 2005 Apr;31(1):27-35.

Berman DS, Kang X, Slomka PJ, Gerlach J, de Yang L, Hayes SW, Friedman JD, Thomson LE, Germano G. “Underestimation of extent of ischemia by gated SPECT myocardial perfusion imaging in patients with left main coronary artery disease.” *J Nucl Cardiol*. 2007 Jul;14(4):521-8.

Tzonevska A, Tzvetkov K, Dimitrova M, Piperkova E. “Assessment of myocardial viability with (99m)Tc-sestamibi -gated SPET images in patients undergoing percutaneous transluminar coronary angioplasty.” *Hell J Nucl Med.* 2005 Jan-Apr;8(1):48-53.

Sharir T. “Role of regional myocardial dysfunction by gated myocardial perfusion SPECT in the prognostic evaluation of patients with coronary artery disease.” *J Nucl Cardiol.* 2005 Jan-Feb;12(1):5-8. No abstract available.

Arrighi JA, Dilsizian V. “Assessment of myocardial viability by radionuclide and echocardiographic techniques: is it simply a sensitivity and specificity issue?” *Curr Opin Cardiol.* 2006 Sep;21(5):450-6. Review.

Ghesani M, Depuey EG, Rozanski A. “Role of F-18 FDG positron emission tomography (PET) in the assessment of myocardial viability.” *Echocardiography.* 2005 Feb;22(2):165-77. Review.

Arrighi JA, Ng CK, Dey HM, Wackers FJ, Soufer R. “Effect of left ventricular function on the assessment of myocardial viability by technectium-99m sestamibi and correlation with positron emission tomography in patients with healed myocardial infarcts or stable angina pectoris, or both.” *Am J Cardiol.* 1997 Oct 15;80(8):1007-13.

Ling LH, Christian TF, Mulvagh SL, Klarich KW, Hauser MF, Nishimura RA,,Pellikka PA. Determining myocardial viability in chronic ischemic left ventricular dysfunction: A prospective comparison of rest-redistribution thallium 201 single-photon emission computed tomography, nitroglycerin-dobutamine echocardiography, and intracoronary myocardial contrast echocardiography. Am Heart J 151:882-9, 2006.

Bisi G, Podio V, Sciagrà R. “Detection of myocardial viability with 99mTc-labelled myocardial perfusion agents.” *Q J Nucl Med.* 1996 Mar;40(1):68-75. Review.

Landoni C, Lucignani G, Paolini G, Zuccari M, Galli L, Di Credico G, Rossetti C, Pelenghi S, Gilardi MC, Fazio F, Grossi A. “Assessment of CABG-related risk in patients with CAD and LVD. Contribution of PET with [18F]FDG to the assessment of myocardial viability.” *J Cardiovasc Surg (Torino).* 1999 Jun;40(3):363-72.

Vom Dahl J, Altehoefer C, Sheehan FH, Buechin P, Schulz G, Schwarz ER, Koch KC, Uebis R, Messmer BJ, Buell U, Hanrath P. “Effect of myocardial viability assessed by technetium-99m-sestamibi SPECT and fluorine-18-FDG PET on clinical outcome in coronary artery disease.” *J Nucl Med.* 1997 May;38(5):742-8.

Yamakawa Y, Takahashi N, Ishikawa T, Uchino K, Mochida Y, Ebina T, Kobayashi T, Matsushita K, Matsumoto K, Kawasaki N, Shimura M, Ohkusu Y, Sumita S, Kimura K, Inoue T, Umemura S. “Clinical usefulness of ECG-gated 18F-FDG PET combined with 99mTC-MIBI gated SPECT for evaluating myocardial viability and function.” *Ann Nucl Med.* 2004 Jul;18(5):375-83.

Grandin C, Wijns W, Melin JA, Bol A, Robert AR, Heyndrickx GR, Michel C, Vanoverschelde JL. “Delineation of myocardial viability with PET.” *J Nucl Med*. 1995 Sep;36(9):1543-52.

Maddahi J, Schelbert H, Brunken R, Di Carli M. “Role of thallium-201 and PET imaging in evaluation of myocardial viability and management of patients with coronary artery disease and left ventricular dysfunction.” *J Nucl Med*. 1994 Apr;35(4):707-15. Review.

Schröter G, Schneider-Eicke J, Schwaiger M. “Assessment of tissue viability with fluorine-18-fluoro-2-deoxyglucose (FDG) and carbon-11-acetate PET imaging.” *Herz.* 1994 Feb;19(1):42-50. Review.

Brunken RC, Mody FV, Hawkins RA, Nienaber C, Phelps ME, Schelbert HR. “Positron emission tomography detects metabolic viability in myocardium with persistent 24-hour single-photon emission computed tomography 201Tl defects.” *Circulation.* 1992 Nov;86(5):1357-69.

Table 8. Evaluation of Ventricular Function

	Indication	**Appropriate Use Criteria (Median Score)**
	Evaluation of Left Ventricular Function	

63	• Assessment of LV function with radionuclide angiography (ERNA or FP (first pass) RNA) • In absence of recent reliable diagnostic information regarding ventricular function obtained with another imaging	
64	• Routine+ use of rest/stress ECG-gating with SPECT or PET myocardial perfusion imaging	
65	• Routine+ use of stress FP RNA in conjunction with rest/stress gated SPECT MPI	
66	• Selective use of stress FP RNA in conjunction with rest/stress gated SPECT MPI • Borderline, mild, or moderate stenoses in three vessels OR moderate or equivocal left main stenosis in left dominant system	
	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	

I. New Lit Search:

Kim IJ, Choo KS, Lee JS, Kim SJ, Kim JH, Kim YK, Kim DS, Cho HJ. "Comparison of gated blood pool SPECT and multi-detector row computed tomography for measurements of left ventricular volumes and ejection fraction in patients with atypical chest pain: validation with radionuclide ventriculography." *Cardiology.* 2007;107(1):8-16. Epub 2006 May 24.

Chareonthaitawee P, Sorajja P, Rajagopalan N, Miller TD, Hodge DO, Frye RL, Gibbons RJ. "Prevalence and prognosis of left ventricular systolic dysfunction in asymptomatic diabetic patients without known coronary artery disease referred for stress single-photon emission computed tomography and assessment of left ventricular function." *Am Heart J.* 2007 Sep;154(3):567-74.

Demir H, Tan YZ, Kozdag G, Isgoren S, Anik Y, Ural D, Demirci A, Berk F. "Comparison of gated SPECT, echocardiography and cardiac magnetic resonance imaging for the assessment of left ventricular ejection fraction and volumes*." Ann Saudi Med.* 2007 Nov-Dec;27(6):415-20.

Khorsand A, Graf S, Eidherr H, Wadsak W, Kletter K, Sochor H, Schuster E, Porenta G. "Gated cardiac 13N-NH3 PET for assessment of left ventricular volumes, mass, and ejection fraction: comparison with electrocardiography-gated 18F-FDG PET." *J Nucl Med.* 2005 Dec;46(12):2009-13.

Bigi R, Bestetti A, Strinchini A, Conte A, Gregori D, Brusoni B, Fiorentini C. "Combined assessment of left ventricular perfusion and function by gated

single-photon emission computed tomography for the risk stratification of high-risk hypertensive patients." *J Hypertens.* 2006 Apr;24(4):767-73.

Kanayama S, Matsunari I, Kajinami K. "Comparison of gated N-13 ammonia PET and gated Tc-99m sestamibi SPECT for quantitative analysis of global and regional left ventricular function." *J Nucl Cardiol.* 2007 Sep-Oct;14(5):680-7.

Sharir T. "Gated myocardial perfusion imaging for the assessment of left ventricular function and volume: from SPECT to PET." *J Nucl Cardiol.* 2007 Sep-Oct;14(5):631-3. No abstract available.

Sciagrà R. "The expanding role of left ventricular functional assessment using gated myocardial perfusion SPECT: the supporting actor is stealing the scene." *Eur J Nucl Med Mol Imaging.* 2007 Jul;34(7):1107-22. Review.

Hida S, Chikamori T, Tanaka H, Usui Y, Igarashi Y, Nagao T, Yamashina A. "Diagnostic value of left ventricular function after stress and at rest in the detection of multivessel coronary artery disease as assessed by electrocardiogram-gated SPECT." *J Nucl Cardiol.* 2007 Jan;14(1):68-74.

Lim TK, Senior R. "Noninvasive modalities for the assessment of left ventricular function: all are equal but some are more equal than others." *J Nucl Cardiol.* 2006 Jul;13(4):445-9. No abstract available.

Schepis T, Gaemperli O, Koepfli P, Valenta I, Strobel K, Brunner A, Leschka S, Desbiolles L, Husmann L, Alkadhi H, Kaufmann PA. "Comparison of 64-slice CT with gated SPECT for evaluation of left ventricular function." *J Nucl Med*. 2006 Aug;47(8):1288-94.

Iskandrian AE, Heo J, Mehta D, Tauxe EL, Yester M, Hall MB, MacGregor JM. "Gated SPECT perfusion imaging for the simultaneous assessment of myocardial perfusion and ventricular function in the BARI 2D trial: an initial report from the Nuclear Core Laboratory." *J Nucl Cardiol.* 2006 Jan-Feb;13(1):83-90.

Djaballah W, Muller MA, Bertrand AC, Marie PY, Chalon B, Djaballah K, Olivier P, Codreanu A, Karcher G, Bertrand A. "Gated SPECT assessment of left ventricular function is sensitive to small patient motions and to low rates of triggering errors: a comparison with equilibrium radionuclide angiography." *J Nucl Cardiol.* 2005 Jan-Feb;12(1):78-85.

Kanayama S, Matsunari I, Hirayama A, Kitayama M, Matsudaira M, Yoneyama T, Nekolla SG, Hisada K, Kajinami K, Takekoshi N. "Assessment of global and regional left ventricular function by electrocardiographic gated N-13 ammonia positron emission tomography in patients with coronary artery disease." *Circ J.* 2005 Feb;69(2):177-82.

Tout DA, Rogers A, Van Aswegen A, Underwood SR. “Left ventricular function parameters obtained from gated myocardial perfusion SPECT imaging: a comparison of two data processing systems.” *Nucl Med Commun*. 2005 Feb;26(2):103-7.

McFalls EO, Baldwin D, Kuskowski M, Liow J, Chesler E, Ward HB. “Utility of positron emission tomography in predicting improved left ventricular ejection fraction after coronary artery bypass grafting among patients with ischemic cardiomyopathy.” *Cardiology.* 2000;93(1-2):105-12.

Santana CA, Shaw LJ, Garcia EV, Soler-Peter M, Candell-Riera J, Grossman GB, Krawczynska EG, Faber TL, Ribera A, Vaccarino V, Halkar R, Di Carli MF. “Incremental prognostic value of left ventricular function by myocardial ECG-gated FDG PET imaging in patients with ischemic cardiomyopathy.” *J Nucl Cardiol.* 2004 Sep-Oct;11(5):542-50.

Slart RH, Bax JJ, de Jong RM, de Boer J, Lamb HJ, Mook PH, Willemsen AT, Vaalburg W, van Veldhuisen DJ, Jager PL. “Comparison of gated PET with MRI for evaluation of left ventricular function in patients with coronary artery disease.” *J Nucl Med.* 2004 Feb;45(2):176-82.

Soufer R, Dey HM, Ng CK, Zaret BL. “Comparison of sestamibi single-photon emission computed tomography with positron emission tomography for estimating left ventricular myocardial viability.” *Am J Cardiol*. 1995 Jun 15;75(17):1214-9.

Appropriate Use Criteria for Cardiac Radionuclide Imaging

Cardiac Radionuclide Imaging
(SPECT or PET Myocardial Perfusion Imaging)

RELEVANT GUIDELINE RECOMMENDATIONS

Assumptions:

1. Panel members were to assume that all radionuclide techniques with specifically 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 (*J Nucl Cardiol* 2006;13:e21-171) It is also assumed that procedures are performed in an accredited facility, with appropriately credentialed physicians.

3. Unless otherwise noted, all indications referred to gated SPECT MPI and PET MPI. All radionuclide perfusion imaging indications also assume gated SPECT MPI and PET MPI 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 (8).
5. In the setting of a known 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.

Table 1. Detection of CAD: Symptomatic

Indication	Guideline Recommendations
Evaluation of Ischemic Equivalent (Non-Acute)	
1. **Evaluation of Ischemic Equivalent (Non-Acute)** ▪ Pre-test Probability of CAD: **Low** ▪ Test Results: **ECG: Interpretable** **AND** ▪ Exercise Ability: **Able to exercise**	***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class IIb** Exercise myocardial perfusion imaging, exercise echocardiography, adenosine or dipyridamole myocardial perfusion imaging, or dobutamine echocardiography as the initial stress test in a patient with a normal rest ECG who is not taking digoxin. *(Level of Evidence: B)* Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)*
2. **Evaluation of Ischemic Equivalent (Non-Acute)** ▪ Pre-test Probability of CAD: **Low** ▪ Test Results: **ECG: Uninterpretable** **OR** ▪ Exercise Ability: **Unable to exercise**	***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class IIb** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)* Exercise myocardial perfusion imaging or exercise echocardiography in patients with a low or high probability of CAD who have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: B) b. More than 1 mm of ST depression. (Level of Evidence: B)

3. **Evaluation of Ischemic Equivalent (Non-Acute)** ▪ Pre-test Probability of CAD: **Intermediate** ▪ Test Results: **ECG: Interpretable** **AND** ▪ Exercise Ability: **Able to exercise**	***RNI (p. 24 - 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class I** Adenosine or dipyridamole myocardial perfusion SPECT in patients with LBBB or electronically-paced ventricular rhythm. *(Level of Evidence: B)* Exercise myocardial perfusion SPECT to identify the extent, severity, and location of ischemia in patients who do not have LBBB or an electronically-paced ventricular rhythm but do have a baseline ECG abnormality which interferes with the interpretation of exercise-induced ST segment changes (ventricular pre-excitation, LVH, digoxin therapy, or more than 1 mm ST depression). *(Level of Evidence: B)* ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class IIb** Exercise myocardial perfusion imaging, exercise echocardiography, adenosine or dipyridamole myocardial perfusion imaging, or dobutamine echocardiography as the initial stress test in a patient with a normal rest ECG who is not taking digoxin. *(Level of Evidence: B)*

4. **Evaluation of Ischemic Equivalent (Non-Acute)** ▪ Pre-test Probability of CAD: **Intermediate** ▪ Test Results: **ECG: Uninterpretable** **OR** ▪ Exercise Ability: **Unable to exercise**	***RNI (p. 24 - 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise.** **Class I** Adenosine or dipyridamole myocardial perfusion SPECT to identify the extent, severity, and location of ischemia. *(Level of Evidence: B)* **Class IIa** Adenosine or dipyridamole myocardial perfusion SPECT as the initial test in patients who are considered to be at high risk (patients with diabetes or patients otherwise defined as having a more than 20% 10-year risk of a coronary heart disease event). *(Level of Evidence: B)* ***RNI PET (p. e27)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk** **Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class IIa** Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are unable to exercise. (Level of Evidence: B) ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class I** 1. Adenosine or dipyridamole myocardial perfusion imaging or dobutamine echocardiography in patients with an intermediate pretest probability of CAD. *(Level of Evidence: B)*

5. **Evaluation of Ischemic Equivalent (Non-Acute)** ▪ Pre-test Probability of CAD: **High** ▪ Test Results: **ECG: Regardless** ▪ Exercise Ability: **Regardless**	***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class IIb** Exercise myocardial perfusion imaging, exercise echocardiography, adenosine or dipyridamole myocardial perfusion imaging, or dobutamine echocardiography as the initial stress test in a patient with a normal rest ECG who is not taking digoxin. *(Level of Evidence: B)* Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)* Exercise myocardial perfusion imaging or exercise echocardiography in patients with a low or high probability of CAD who have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: B) b. More than 1 mm of ST depression. (Level of Evidence: B) **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class IIb** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. (Level of Evidence: B) ***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIa** Exercise myocardial perfusion SPECT as the initial test in patients who are considered to be at high risk (patients with diabetes or patients otherwise defined as having a more than 20% 10-year risk of a coronary heart disease event). *(Level of Evidence: B)* **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise.** **Class IIa** Adenosine or dipyridamole myocardial perfusion SPECT as the initial test in patients who are considered to be at high risk (patients with diabetes or patients otherwise defined as having a more than 20% 10-year risk of a coronary heart disease event). *(Level of Evidence: B)* ***RNI PET (p. e27)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class IIa** Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are unable to exercise. (Level of Evidence: B) Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are able to exercise but have LBBB or an electronically-paced rhythm. (Level of Evidence: B)

Acute Chest Pain	
6. Acute Chest Pain ▪ **Possible ACS** ▪ Test Results: **ECG: no ischemic changes or with LBBB or electronically ventricular paced rhythm** **Low-risk TIMI score** **Peak Troponin: borderline, equivocal, minimally elevated**	***UA/NSTEMI (p. e11)*** **Immediate Management** **Class I** In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow up 12-lead ECG and biomarker measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative stress diagnostic test can be managed as outpatients. (Level of Evidence: C) Patients with possible ACS and negative cardiac biomarkers who are unable to exercise or who have an abnormal resting ECG should undergo a pharmacological stress test. *(Level of Evidence: B* **Immediate Management (p. e31)** **Class IIa** In patients with suspected ACS with a low or intermediate probability of CAD, in whom the follow-up 12-lead ECG and cardiac biomarkers measurements are normal, performance of a noninvasive coronary imaging test (i.e., CCTA) is reasonable as an alternative to stress testing. (Level of Evidence: B) ***RNI (p. 7, Table 2)*** **Recommendations for Emergency Department Imaging for Suspected Acute Coronary Syndromes** **Class III** Routine imaging of patients with myocardial ischemia necrosis already documented clinically, by ECG and/or serum markers or enzymes. *(Level of Evidence: C)*

7. **Acute Chest Pain** ▪ **Possible ACS** ▪ Test Results: **ECG: no ischemic changes or with LBBB or electronically ventricular paced rhythm** **High-risk TIMI score** **Peak Troponin: borderline, equivocal, minimally elevated**	***UA/NSTEMI (p. e11)*** **Immediate Management** **Class I** In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow up 12-lead ECG and biomarker measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative stress diagnostic test can be managed as outpatients. (Level of Evidence: C) Patients with possible ACS and negative cardiac biomarkers who are unable to exercise or who have an abnormal resting ECG should undergo a pharmacological stress test. *(Level of Evidence: B* **Immediate Management (p. e31)** **Class IIa** In patients with suspected ACS with a low or intermediate probability of CAD, in whom the follow-up 12-lead ECG and cardiac biomarkers measurements are normal, performance of a noninvasive coronary imaging test (i.e., CCTA) is reasonable as an alternative to stress testing. (Level of Evidence: B) ***RNI (p. 7, Table 2)*** **Recommendations for Emergency Department Imaging for Suspected Acute Coronary Syndromes** **Class III** Routine imaging of patients with myocardial ischemia necrosis already documented clinically, by ECG and/or serum markers or enzymes. *(Level of Evidence: C)*

8. **Acute Chest Pain** ▪ **Possible ACS** ▪ Test Results: **ECG: no ischemic changes or with LBBB or electronically ventricular paced rhythm** **Low-risk TIMI score** ▪ **Negative peak troponin levels**	***UA/NSTEMI (p. e11)*** **Immediate Management** **Class I** In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow up 12-lead ECG and biomarker measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative stress diagnostic test can be managed as outpatients. (Level of Evidence: C) Patients with possible ACS and negative cardiac biomarkers who are unable to exercise or who have an abnormal resting ECG should undergo a pharmacological stress test. *(Level of Evidence: B* **Immediate Management (p. e31)** **Class IIa** In patients with suspected ACS with a low or intermediate probability of CAD, in whom the follow-up 12-lead ECG and cardiac biomarkers measurements are normal, performance of a noninvasive coronary imaging test (i.e., CCTA) is reasonable as an alternative to stress testing. (Level of Evidence: B) ***RNI (p. 7, Table 2)*** **Recommendations for Emergency Department Imaging for Suspected Acute Coronary Syndromes** **Class III** Routine imaging of patients with myocardial ischemia necrosis already documented clinically, by ECG and/or serum markers or enzymes. *(Level of Evidence: C)*

9. **Acute Chest Pain** ▪ **Possible ACS** ▪ Test Results: **ECG: no ischemic changes or with LBBB or electronically ventricular paced rhythm** **High-risk TIMI score** ▪ **Negative peak troponin levels**	***UA/NSTEMI (p. e11)*** **Immediate Management** **Class I** In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow up 12-lead ECG and biomarker measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative stress diagnostic test can be managed as outpatients. (Level of Evidence: C) Patients with possible ACS and negative cardiac biomarkers who are unable to exercise or who have an abnormal resting ECG should undergo a pharmacological stress test. *(Level of Evidence: B* **Immediate Management (p. e31)** **Class IIa** In patients with suspected ACS with a low or intermediate probability of CAD, in whom the follow-up 12-lead ECG and cardiac biomarkers measurements are normal, performance of a noninvasive coronary imaging test (i.e., CCTA) is reasonable as an alternative to stress testing. (Level of Evidence: B) ***RNI (p. 7, Table 2)*** **Recommendations for Emergency Department Imaging for Suspected Acute Coronary Syndromes** **Class III** Routine imaging of patients with myocardial ischemia necrosis already documented clinically, by ECG and/or serum markers or enzymes. *(Level of Evidence: C)*

10. **Acute Chest Pain** ▪ **Definite ACS**	***UA/NSTEMI (p. e11)*** **Immediate Management** **Class I** In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow up 12-lead ECG and biomarker measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative stress diagnostic test can be managed as outpatients. (Level of Evidence: C) Patients with possible ACS and negative cardiac biomarkers who are unable to exercise or who have an abnormal resting ECG should undergo a pharmacological stress test. *(Level of Evidence: B* **Immediate Management (p. e31)** **Class IIa** In patients with suspected ACS with a low or intermediate probability of CAD, in whom the follow-up 12-lead ECG and cardiac biomarkers measurements are normal, performance of a noninvasive coronary imaging test (i.e., CCTA) is reasonable as an alternative to stress testing. (Level of Evidence: B) ***RNI (p. 7, Table 2)*** **Recommendations for Emergency Department Imaging for Suspected Acute Coronary Syndromes** **Class III** Routine imaging of patients with myocardial ischemia necrosis already documented clinically, by ECG and/or serum markers or enzymes. *(Level of Evidence: C)*
Acute Chest Pain (Rest Imaging Only)	

11. **Acute Chest Pain (Rest Imaging Only)** ▪ **Possible ACS** ▪ Test Results: **ECG: no ischemic changes or with LBBB or electronically ventricular paced rhythm** ▪ **Initial troponin negative** ▪ **Recent or on-going chest pain**	***UA/NSTEMI (p. e11)*** **Immediate Management** **Class I** In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow up 12-lead ECG and biomarker measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative stress diagnostic test can be managed as outpatients. (Level of Evidence: C) Patients with possible ACS and negative cardiac biomarkers who are unable to exercise or who have an abnormal resting ECG should undergo a pharmacological stress test. *(Level of Evidence: B* **Immediate Management (p. e31)** **Class IIa** In patients with suspected ACS with a low or intermediate probability of CAD, in whom the follow-up 12-lead ECG and cardiac biomarkers measurements are normal, performance of a noninvasive coronary imaging test (i.e., CCTA) is reasonable as an alternative to stress testing. (Level of Evidence: B) ***RNI (p. 7, Table 2)*** **Recommendations for Emergency Department Imaging for Suspected Acute Coronary Syndromes** **Class III** Routine imaging of patients with myocardial ischemia necrosis already documented clinically, by ECG and/or serum markers or enzymes. *(Level of Evidence: C)*

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

Indication	Guideline Recommendations
Asymptomatic	
12. **Asymptomatic** ▪ CHD Risk (ATP III risk criteria): **Low**	***Stable Angina (p. 27)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Asymptomatic Patients** **Class III** Exercise myocardial perfusion imaging, exercise echocardiography, adenosine or dipyridamole myocardial perfusion imaging, or dobutamine echocardiography as the initial stress test in an asymptomatic patient with a normal rest ECG who is not taking digoxin. *(Level of Evidence: C)* Adenosine or dipyridamole myocardial perfusion imaging or dobutamine echocardiography in asymptomatic patients who are able to exercise and do not have left bundle-branch block or electronically paced ventricular rhythm. *(Level of Evidence: C)*

13. **Asymptomatic** ▪ CHD Risk (ATP III risk criteria): **Moderate** **ECG Interpretable**	***Stable Angina (p. 27)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Asymptomatic Patients** **Class III** Exercise myocardial perfusion imaging, exercise echocardiography, adenosine or dipyridamole myocardial perfusion imaging, or dobutamine echocardiography as the initial stress test in an asymptomatic patient with a normal rest ECG who is not taking digoxin. *(Level of Evidence: C)* Adenosine or dipyridamole myocardial perfusion imaging or dobutamine echocardiography in asymptomatic patients who are able to exercise and do not have left bundle-branch block or electronically paced ventricular rhythm. *(Level of Evidence: C)* ***RNI PET (p. e27)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk** **Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class IIa** Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are unable to exercise. (Level of Evidence: B) Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are able to exercise but have LBBB or an electronically- paced rhythm. (Level of Evidence: B)

14. **Asymptomatic** ▪ CHD Risk (ATP III risk criteria): **Moderate** **ECG Uninterpretable**	***RNI PET (p. e27)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk** **Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class IIa** Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are unable to exercise. (Level of Evidence: B) Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are able to exercise but have LBBB or an electronically- paced rhythm. (Level of Evidence: B)

15. **Asymptomatic** ▪ CHD Risk (ATP III risk criteria): **High**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIa** Exercise myocardial perfusion SPECT as the initial test in patients who are considered to be at high risk (patients with diabetes or patients otherwise defined as having a more than 20% 10-year risk of a coronary heart disease event). *(Level of Evidence: B)* **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise.** **Class IIa** Adenosine or dipyridamole myocardial perfusion SPECT as the initial test in patients who are considered to be at high risk (patients with diabetes or patients otherwise defined as having a more than 20% 10-year risk of a coronary heart disease event). *(Level of Evidence: B)* ***RNI PET (p. e27)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class IIa** Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are unable to exercise. (Level of Evidence: B) Adenosine or dipyridamole myocardial perfusion PET to identify the extent, severity, and location of ischemia as the initial diagnostic test in patients who are able to exercise but have LBBB or an electronically-paced rhythm. (Level of Evidence: B) ***Stable Angina (p. 27)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Asymptomatic Patients** **Class III** Exercise myocardial perfusion imaging, exercise echocardiography, adenosine or dipyridamole myocardial perfusion imaging, or dobutamine echocardiography as the initial stress test in an asymptomatic patient with a normal rest ECG who is not taking digoxin. *(Level of Evidence: C)* Adenosine or dipyridamole myocardial perfusion imaging or dobutamine echocardiography in asymptomatic patients who are able to exercise and do not have left bundle-branch block or electronically paced ventricular rhythm. *(Level of Evidence: C)*

New-Onset or Diagnosed Heart Failure with LV Systolic Dysfunction Without Ischemic Equivalent	
16. **New Onset or Newly Diagnosed Heart Failure with LV Systolic Dysfunction without Ischemic Equivalent** ▪ Test Results: **No prior CAD evaluation** ▪ Context: **No planned coronary angiography**	***RNI (p. 27)*** **Recommendations for the Use of Radionuclide Imaging in Patients With Heart Failure: Fundamental Assessment** **Class IIa** Assessment of the copresence of CAD in patients without angina. *(Level of Evidence: B)* ***Heart Failure (p. 9)*** **Recommendations for the Initial Clinical Assessment of Patients Presenting with HF** **Class IIb** Noninvasive imaging may be considered to define the likelihood of coronary artery disease in patients with HF and LV dysfunction. *(Level of Evidence: C)*
New Onset Atrial Fibrillation	
17. **New Onset Atrial Fibrillation** ▪ Context: **Part of the evaluation when etiology unclear**	**None**
Ventricular Tachycardia	

18. **Ventricular Tachycardia** ▪ CHD Risk (ATP III risk criteria): **Low**	***Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death*** **Left Ventricular Function and Imaging (p. e15)** **Class I** ET with an imaging modality (echocardiography or nuclear perfusion [single-photon emission computed tomography (SPECT)]) is recommended to detect silent ischemia in patients with VA who have an intermediate probability of having CHD by age, symptoms, and gender, and in whom ECG assessment is less reliable because of digoxin use, left ventricular (LV) hypertrophy, greater than 1 mm ST-segment depression at rest, Wolff-Parkinson-White Syndrome or left bundle-branch block. (Level of Evidence: B) Pharmacological stress testing with an imaging modality (echocardiography or myocardial perfusion SPECT) is recommended to detect silent ischemia in patients with VA who have an intermediate probability of having CHD by age, symptoms, and gender and are physically unable to perform a symptom-limited exercise test. (Level of Evidence: B) **Polymorphic Ventricular Tachycardia (p. e23)** **Class I** Urgent angiography with a view to revascularization should be considered for patients with polymorphic VT when myocardial ischemia cannot be excluded. (Level of Evidence: C)

19.	**Ventricular Tachycardia** ▪ CHD Risk (ATP III risk criteria): **Moderate or High**	***Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death*** **Left Ventricular Function and Imaging (p. e15)** **Class I** ET with an imaging modality (echocardiography or nuclear perfusion [single-photon emission computed tomography (SPECT)]) is recommended to detect silent ischemia in patients with VA who have an intermediate probability of having CHD by age, symptoms, and gender, and in whom ECG assessment is less reliable because of digoxin use, left ventricular (LV) hypertrophy, greater than 1 mm ST-segment depression at rest, Wolff-Parkinson-White Syndrome or left bundle-branch block. (Level of Evidence: B) Pharmacological stress testing with an imaging modality (echocardiography or myocardial perfusion SPECT) is recommended to detect silent ischemia in patients with VA who have an intermediate probability of having CHD by age, symptoms, and gender and are physically unable to perform a symptom-limited exercise test. (Level of Evidence: B) **Polymorphic Ventricular Tachycardia (p. e23)** **Class I** Urgent angiography with a view to revascularization should be considered for patients with polymorphic VT when myocardial ischemia cannot be excluded. (Level of Evidence: C)
Syncope		
20.	**Syncope** ▪ CHD Risk (ATP III risk criteria): **Low**	***None***
21.	**Syncope** ▪ CHD Risk (ATP III risk criteria): **Moderate or High**	***None***
Elevated Troponin		

22.	**Elevated Troponin** ▪ Troponin elevation without additional evidence of acute coronary syndrome	***RNI (p. 7, Table 2)*** **Recommendations for Emergency Department Imaging for Suspected Acute Coronary Syndromes** **Class III** Routine imaging of patients with myocardial ischemia necrosis already documented clinically, by ECG and/or serum markers or enzymes. *(Level of Evidence: C)*

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

Indication	Guideline Recommendations
Asymptomatic OR Stable Symptoms Normal Prior Stress Imaging Study	
23. **Asymptomatic OR Stable Symptoms Normal Prior Stress Imaging Study** ▪ CHD Risk (ATP III risk criteria): **Low** ▪ Context: **Last stress imaging study done less than 2 years ago**	**None**

24.	**Asymptomatic OR Stable Symptoms Normal Prior Stress Imaging Study (** ▪ CHD Risk (ATP III risk criteria): **Intermediate to High** ▪ Context: **Last stress imaging study done more than 2 years ago**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIb** Exercise myocardial perfusion SPECT in asymptomatic patients who have a high-risk occupation. (*Level of Evidence: B*) **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise.** **Class IIb** Adenosine or dipyridamole myocardial perfusion SPECT in asymptomatic patients who have a high risk occupation. *(Level of Evidence: C)*
25	**Asymptomatic OR Stable Symptoms Normal Prior Stress Imaging Study** ▪ CHD Risk (ATP III risk criteria): **Low** ▪ Context: **Last stress imaging study done more than 2 years ago**	**None**

26. **Asymptomatic OR Stable Symptoms** **Normal Prior Stress Imaging Study (** ▪ CHD Risk (ATP III risk criteria): **Intermediate to High** ▪ Context: **Last stress imaging study done more than 2 years ago**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIb** Exercise myocardial perfusion SPECT in asymptomatic patients who have a high-risk occupation. (*Level of Evidence: B*) **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise.** **Class IIb** Adenosine or dipyridamole myocardial perfusion SPECT in asymptomatic patients who have a high risk occupation. *(Level of Evidence: C)*
Asymptomatic OR Stable Symptoms **Abnormal Coronary Angiography OR Abnormal Prior Stress Imaging Study, No Prior Revascularization**	

27.	**Asymptomatic OR Stable Symptoms Abnormal Coronary Angiography OR Abnormal Prior Stress Imaging Study, No Prior Revascularization** ▪ Test Results **Known CAD on coronary angiography OR prior abnormal stress imaging study** ▪ Timeframe: **Last stress imaging study done less than 2 years ago**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIb** Repeat exercise myocardial perfusion SPECT 1 to 3 years after initial perfusion imaging in patients with known or a high likelihood of CAD, stable symptoms, and a predicted annual mortality of more than 1%, to redefine the risk of a cardiac event. *(Level of Evidence: C)* Repeat exercise myocardial perfusion SPECT on cardiac active medications after initial abnormal perfusion imaging to assess the efficacy of medical therapy. *(Level of Evidence: C)* **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who are Unable to Exercise** **Class IIb** Repeat adenosine or dipyridamole MPI 1 to 3 years after initial perfusion imaging in patients with known or a high likelihood of CAD, stable symptoms, and a predicted annual mortality of more than 1%, to redefine the risk of a cardiac event. *(Level of Evidence: C)* Repeat adenosine or dipyridamole myocardial perfusion SPECT on cardiac active medications after initial abnormal perfusion imaging to assess the efficacy of medical therapy. *(Level of Evidence: C)* ***RNI PET (p. e26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk** **Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class I** Adenosine or dipyridamole myocardial perfusion PET in patients in whom an appropriately indicated myocardial perfusion SPECT study has been found to be equivocal for diagnostic or risk stratification purposes. (Level of Evidence: B)

28.	**Asymptomatic OR Stable Symptoms Abnormal Coronary Angiography OR Abnormal Prior Stress Imaging Study, No Prior Revascularization** ▪ Test Results **Known CAD on coronary angiography OR prior abnormal stress imaging** ▪ Timeframe: **Last stress imaging study done more than or equal to 2 years ago**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIb** Repeat exercise myocardial perfusion SPECT 1 to 3 years after initial perfusion imaging in patients with known or a high likelihood of CAD, stable symptoms, and a predicted annual mortality of more than 1%, to redefine the risk of a cardiac event. *(Level of Evidence: C)* Repeat exercise myocardial perfusion SPECT on cardiac active medications after initial abnormal perfusion imaging to assess the efficacy of medical therapy. *(Level of Evidence: C)* **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who are Unable to Exercise** **Class IIb** Repeat adenosine or dipyridamole MPI 1 to 3 years after initial perfusion imaging in patients with known or a high likelihood of CAD, stable symptoms, and a predicted annual mortality of more than 1%, to redefine the risk of a cardiac event. *(Level of Evidence: C)* Repeat adenosine or dipyridamole myocardial perfusion SPECT on cardiac active medications after initial abnormal perfusion imaging to assess the efficacy of medical therapy. *(Level of Evidence: C)* ***RNI PET (p. e26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk** **Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class I** Adenosine or dipyridamole myocardial perfusion PET in patients in whom an appropriately indicated myocardial perfusion SPECT study has been found to be equivocal for diagnostic or risk stratification purposes. (Level of Evidence: B)
Prior Non-Invasive Evaluation		

29. **Prior Non-Invasive Evaluation** ▪ Test Results **Equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern.**	***RNI PET (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk** **Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class I** Adenosine or dipyridamole myocardial perfusion PET in patients in whom an appropriately indicated myocardial perfusion SPECT study has been found to be equivocal for diagnostic or risk stratification purposes. (Level of Evidence: B)
New or Worsening Symptoms	

30.	**New or Worsening Symptoms** ▪ Test Results **Abnormal Coronary Angiography OR Abnormal Prior Stress Imaging Study**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class I** Repeat exercise MPI after initial perfusion imaging in patients whose symptoms have changed to redefine the risk for cardiac event. *(Level of Evidence: C)* **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who are Unable to Exercise** **Class I** Adenosine or dipyridamole myocardial perfusion SPECT after initial perfusion imaging in patients whose symptoms have changed to redefine the risk for cardiac event. (*Level of Evidence: C)* ***RNI PET (p. e26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class I** Adenosine or dipyridamole myocardial perfusion PET in patients in whom an appropriately indicated myocardial perfusion SPECT study has been found to be equivocal for diagnostic or risk stratification purposes. (Level of Evidence: B) ***Stable Angina (p. 91)*** **Recommendations for Echocardiography, Treadmill Exercise Testing, Stress Imaging Studies, and Coronary Angiography During Patient Follow-up** **Class I** Stress radionuclide imaging or stress echocardiography procedures for patients without prior revascularization who have a significant change in clinical status and are unable to exercise or have one of the following ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: C) b. Electronically paced ventricular rhythm. (Level of Evidence: C) c. More than 1 mm of rest ST depression. (Level of Evidence: C) d. Complete left bundle-branch block. (Level of Evidence: C) ***Stable Angina (p. 91)*** **Recommendations for Echocardiography, Treadmill Exercise Testing, Stress Radionuclide Imaging, Stress Echocardiography Studies, and Coronary Angiography During Patient Follow-up** **Class I** Stress radionuclide imaging or stress echocardiography procedures for patients who have a significant change in clinical status and required a stress imaging procedure on their initial evaluation because of equivocal or intermediate-risk treadmill results. (Level of Evidence: C

31.	**New or Worsening Symptoms** ▪ Test Results **Normal Coronary Angiography OR Normal Prior Stress Imaging Study**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class I** Repeat exercise MPI after initial perfusion imaging in patients whose symptoms have changed to redefine the risk for cardiac event. *(Level of Evidence: C)* **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who are Unable to Exercise** **Class I** Adenosine or dipyridamole myocardial perfusion SPECT after initial perfusion imaging in patients whose symptoms have changed to redefine the risk for cardiac event. (*Level of Evidence: C)* ***RNI PET (p. e26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class I** Adenosine or dipyridamole myocardial perfusion PET in patients in whom an appropriately indicated myocardial perfusion SPECT study has been found to be equivocal for diagnostic or risk stratification purposes. (Level of Evidence: B) ***Stable Angina (p. 91)*** **Recommendations for Echocardiography, Treadmill Exercise Testing, Stress Imaging Studies, and Coronary Angiography During Patient Follow-up** **Class I** Stress radionuclide imaging or stress echocardiography procedures for patients without prior revascularization who have a significant change in clinical status and are unable to exercise or have one of the following ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: C) b. Electronically paced ventricular rhythm. (Level of Evidence: C) c. More than 1 mm of rest ST depression. (Level of Evidence: C) d. Complete left bundle-branch block. (Level of Evidence: C) ***Stable Angina (p. 91)*** **Recommendations for Echocardiography, Treadmill Exercise Testing, Stress Radionuclide Imaging, Stress Echocardiography Studies, and Coronary Angiography During Patient Follow-up** **Class I** Stress radionuclide imaging or stress echocardiography procedures for patients who have a significant change in clinical status and required a stress imaging procedure on their initial evaluation because of equivocal or intermediate-risk treadmill results. (Level of Evidence: C

Coronary Angiography (Invasive or Noninvasive)		
32.	**Coronary Angiography (Invasive or Noninvasive)** ▪ Test Results: **Coronary stenosis or anatomic abnormality of uncertain significance**	***RNI PET (p. e26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk** **Stratification of Patients With an Intermediate or High Likelihood of CAD** **Class I** Adenosine or dipyridamole myocardial perfusion PET in patients in whom an appropriately indicated myocardial perfusion SPECT study has been found to be equivocal for diagnostic or risk stratification purposes. (Level of Evidence: B)
Asymptomatic Prior Coronary Calcium Agatston Score		
33.	**Asymptomatic Prior Coronary Calcium Agatston Score** ▪ Test Results: **Agatson score less than 100**	**None**
34.	**Asymptomatic Prior Coronary Calcium Agatston Score** ▪ CHD Risk (ATP III risk criteria): **Low to Intermediate** ▪ Test Results: **Agatston score between 100 and 400**	**None**

35.	**Asymptomatic** **Prior Coronary Calcium Agatston Score** ▪ CHD Risk (ATP III risk criteria): **High** ▪ Test Results: **Agatston score between 100-400**	**None**

36.	**Asymptomatic** **Prior Coronary Calcium Agatston Score** ▪ Test Results: **Agatston score greater than 400**	***Stable Angina (p. 43)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Risk Stratification in Asymptomatic Patients** **Class IIb** Exercise perfusion imaging or exercise echocardiography in asymptomatic patients with severe coronary calcification on EBCT who are able to exercise and have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. *(Level of Evidence: C)* b. More than 1 mm of ST depression at rest. *(Level of Evidence: C)* Adenosine or dipyridamole myocardial perfusion imaging or dobutamine echocardiography in patients with possible myocardial ischemia on ambulatory ECG monitoring or with severe coronary calcification on EBCT who are unable to exercise. *(Level of Evidence: C)* ***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIb** Exercise myocardial perfusion SPECT in symptomatic or asymptomatic patients who have severe coronary calcification (CT CCS more than 75th percentile for age and sex) in the presence on the resting ECG of pre-excitation (Wolff-Parkinson-White) syndrome or more than 1 mm ST segment depression.(*Level of Evidence: B*) **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise** **Class IIb** Adenosine or dipyridamole myocardial perfusion SPECT in symptomatic or asymptomatic patients who have severe coronary calcification (CT CCS more than the 75th percentile for age and sex) in the presence on the resting ECG of LBBB or an electronically-paced ventricular system. (*Level of Evidence: B*)

Duke Treadmill Score		
37.	**Duke Treadmill Score** ▪ Test Results: **Low-Risk Duke treadmill score**	**None**
38.	**Duke Treadmill Score** ▪ Test Results: **Intermediate-Risk Duke treadmill score**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class I** Exercise myocardial perfusion SPECT in patients with intermediate Duke treadmill score. (*Level of Evidence: B*)
39.	**Duke Treadmill Score** ▪ Test Results: **High-Risk Duke treadmill score**	**None**

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

Indication	**Guideline Recommendations**
Low-Risk Surgery	

40. **Low Risk Surgery** ▪ Context: **Preoperative evaluation for non-cardiac surgery risk assessment**	***Peri-op (pg. e169)*** Peri-op guideline flow chart (figure 1) ***Peri-op (pg. e180)*** **Recommendations for Noninvasive Stress Testing Before Noncardiac Surgery** **Class III** Noninvasive testing is not useful for patients undergoing low-risk noncardiac surgery (*Level of Evidence: C)* ***Peri-op Errata*** **Recommendations for Perioperative Cardiac Assessment** **Class I** Patients who are at low risk for surgery are recommended to proceed to planned surgery (*Level of Evidence: B)* ***RNI (p. 27)*** **Recommendations: Cardiac Stress Perfusion Imaging Before Noncardiac Surgery** **Class III** Routine screening of asymptomatic men or women with low pretest likelihood of CAD. (*Level of Evidence: C)* Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)* Exercise myocardial perfusion imaging or exercise echocardiography in patients with a low or high probability of CAD who have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: B) b. More than 1 mm of ST depression. (Level of Evidence: B)
Intermediate Risk Surgery	

41. **Intermediate Risk Surgery** ▪ Perioperative Risk Predictor: **Moderate to Good Functional Capacity (greater than or equal to 4 METs)**	***Peri-op (pg. e169)*** Peri-op guideline flow chart ***Peri-op (pg. e180)*** **Recommendations for Noninvasive Stress Testing Before Noncardiac Surgery** **Class III** Noninvasive testing is not useful for patients with no clinical risk factors undergoing intermediate-risk noncardiac surgery (*Level of Evidence: C)* ***Peri-op Errata*** **Recommendations for Perioperative Cardiac Assessment** **Class I** Patients with good functional capacity (MET level greater than or equal to 7) without symptoms should proceed to planned surgery. (*Level of Evidence: B)* ***RNI (p. 27)*** **Recommendations: Cardiac Stress Perfusion Imaging Before Noncardiac Surgery** **Class III** Routine screening of asymptomatic men or women with low pretest likelihood of CAD. (*Level of Evidence: C)* Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)* Exercise myocardial perfusion imaging or exercise echocardiography in patients with a low or high probability of CAD who have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: B) b. More than 1 mm of ST depression. (Level of Evidence: B)

42. **Intermediate Risk Surgery** ▪ Perioperative Risk Predictor: **No clinical risk factors**	***Peri-op (pg. e169)*** Peri-op guideline flow chart ***Peri-op (pg. e180)*** **Recommendations for Noninvasive Stress Testing Before Noncardiac Surgery** **Class III** Noninvasive testing is not useful for patients with no clinical risk factors undergoing intermediate-risk noncardiac surgery (*Level of Evidence: C)* ***Peri-op Errata*** **Recommendations for Perioperative Cardiac Assessment** **Class I** Patients with good functional capacity (MET level greater than or equal to 7) without symptoms should proceed to planned surgery. (*Level of Evidence: B)*

43. **Intermediate Risk Surgery** ▪ Perioperative Risk Predictor: **Greater than or equal to 1 clinical risk factor** ▪ Exercise Tolerance: **Poor or unknown functional capacity (less than 4 METs)**	***Peri-op (pg. e169)*** Peri-op guideline flow chart ***Peri-op Errata*** **Recommendations for Perioperative Cardiac Assessment** **Class IIa** Patients with poor (less than 4 METs) or unknown functional capacity and 3 or more clinical risk factors‖ who are scheduled for intermediate risk surgery are probably recommended to proceed with planned surgery with heart rate control¶. (Level of Evidence: B) Patients with poor (less than 4 METs) or unknown functional capacity and 1 or 2 clinical risk factors‖ who are scheduled for vascular or intermediate risk surgery are probably recommended to proceed with planned surgery with heart rate control¶. *(Level of Evidence: B*) **Class IIb** Noninvasive testing might be considered if it will change management for patients with poor (less than 4 METs) or unknown functional capacity and 3 or more clinical risk factors‖ who are scheduled for intermediate risk surgery. (*Level of Evidence: B*) Noninvasive testing might be considered if it will change management for patients with poor (less than 4 METs) or unknown functional capacity and 1 or 2 clinical risk factors‖ who are scheduled for vascular or intermediate risk surgery. (Level of Evidence: B) ***Peri-op (pg. e180)*** **Recommendations for Noninvasive Stress Testing Before Noncardiac Surgery** **Class IIb** Noninvasive stress testing may be considered for patients with at least 1 to 2 clinical risk factors and poor functional capacity (less than 4 METs) who require intermediate-risk noncardiac surgery if it will change management. (*Level of Evidence: B)* *See Table 2 for active clinical conditions. †See Class III recommendations in section 5.2.3. Noninvasive Stress Testing in full text guideline. ‡See Table 3 for estimated MET level equivalent. §Noninvasive testing may be considered before surgery in specific patient populations 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 (see Table 12) for populations in which this has been shown to reduce cardiac morbidity/mortality.

44. **Intermediate Risk Surgery** ▪ Context: **Asymptomatic up to 1 year post normal catheterization, non-invasive test, or previous revascularization**	***Peri-op (pg. e169)*** Peri-op guideline flow chart ***Peri-op Errata*** **Recommendations for Perioperative Cardiac Assessment** **Class IIa** Patients with poor (less than 4 METs) or unknown functional capacity and 3 or more clinical risk factors‖ who are scheduled for intermediate risk surgery are probably recommended to proceed with planned surgery with heart rate control¶. (Level of Evidence: B) Patients with poor (less than 4 METs) or unknown functional capacity and 1 or 2 clinical risk factors‖ who are scheduled for vascular or intermediate risk surgery are probably recommended to proceed with planned surgery with heart rate control¶. *(Level of Evidence: B*) **Class IIb** Noninvasive testing might be considered if it will change management for patients with poor (less than 4 METs) or unknown functional capacity and 3 or more clinical risk factors‖ who are scheduled for intermediate risk surgery. (*Level of Evidence: B*) Noninvasive testing might be considered if it will change management for patients with poor (less than 4 METs) or unknown functional capacity and 1 or 2 clinical risk factors‖ who are scheduled for vascular or intermediate risk surgery. (Level of Evidence: B)
Vascular Surgery	
45. **Vascular Surgery** ▪ Exercise Tolerance: **Moderate to Good Functional Capacity (greater than or equal to 4 METs)**	***RNI (p. 27)*** **Recommendations: Cardiac Stress Perfusion Imaging Before Noncardiac Surgery** **Class III** Routine screening of asymptomatic men or women with low pretest likelihood of CAD. (*Level of Evidence: C)* Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)* Exercise myocardial perfusion imaging or exercise echocardiography in patients with a low or high probability of CAD who have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: B) b. More than 1 mm of ST depression. (Level of Evidence: B)

46. **Vascular Surgery** ▪ Perioperative Risk Predictor: **No clinical risk factors**	***Peri-op (pg. e169)*** Peri-op guideline flow chart ***Peri-op Errata*** **Recommendations for Perioperative Cardiac Assessment** **Class IIa** Patients with poor (less than 4 METs) or unknown functional capacity and 1 or 2 clinical risk factors‖ who are scheduled for vascular or intermediate risk surgery are probably recommended to proceed with planned surgery with heart rate control¶. *(Level of Evidence: B*) **Class IIb** Noninvasive testing might be considered if it will change management for patients with poor (less than 4 METs) or unknown functional capacity and 1 or 2 clinical risk factors‖ who are scheduled for vascular or intermediate risk surgery. (Level of Evidence: B) ***RNI (p. 27)*** **Recommendations: Cardiac Stress Perfusion Imaging Before Noncardiac Surgery** **Class III** Routine screening of asymptomatic men or women with low pretest likelihood of CAD. (*Level of Evidence: C)* Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)* Exercise myocardial perfusion imaging or exercise echocardiography in patients with a low or high probability of CAD who have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: B) b. More than 1 mm of ST depression. (Level of Evidence: B)

47. **Vascular Surgery** ▪ Perioperative Risk Predictor: **Greater than or equal to 1 clinical risk factor** ▪ Exercise Tolerance: **Poor or unknown functional capacity (less than 4 METs)**	***Peri-op (pg. e169)*** Peri-op guideline flow chart ***Peri-op (pg. e180)*** **Recommendations for Noninvasive Stress Testing Before Noncardiac Surgery** **Class IIB** Noninvasive stress testing may be considered for patients with at least 1 to 2 clinical risk factors and good functional capacity (greater than or equal to 7 METs) who are undergoing vascular surgery (Level of Evidence: B) ***RNI (p. 27)*** **Recommendations: Cardiac Stress Perfusion Imaging Before Noncardiac Surgery** **Class III** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)* Exercise myocardial perfusion imaging or exercise echocardiography in patients with a low or high probability of CAD who have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: B) b. More than 1 mm of ST depression. (Level of Evidence: B)

48. **Vascular Surgery** ▪ Timeframe: **Asymptomatic up to 1 year post normal catheterization, non-invasive test, or previous revascularization**	***RNI (p. 27)*** **Recommendations: Cardiac Stress perfusion Imaging Before Noncardiac Surgery** **Class IIb** Routine assessment of active, asymptomatic patients who have remained stable for up to 5 years after CABG surgery. (*Level of Evidence: C*) Routine evaluation of active, asymptomatic patients who have remained stable for up to 2 years after previous abnormal coronary angiography or noninvasive assessment of myocardial perfusion. *(Level of Evidence: C)* Diagnosis of restenosis and regional ischemia in active, asymptomatic patients within weeks to months after PCI. *(Level of Evidence: C)* **Class III** Routine screening of asymptomatic men or women with low pretest likelihood of CAD. (*Level of Evidence: C)* Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with a low or high probability of CAD in the absence of electronically paced ventricular rhythm or left bundle-branch block. *(Level of Evidence: B)* Exercise myocardial perfusion imaging or exercise echocardiography in patients with a low or high probability of CAD who have one of the following baseline ECG abnormalities: a. Pre-excitation (Wolff-Parkinson-White) syndrome. (Level of Evidence: B) b. More than 1 mm of ST depression. (Level of Evidence: B)

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

Indication	**Guideline Recommendations**
STEMI	
49. **STEMI** ▪ **Primary PCI with complete revascularization** ▪ **No recurrent symptoms**	***RNI (p. 8, Table 3)*** **Recommendations for Use of Radionuclide Testing in Diagnosis, Risk Assessment, Prognosis, and Assessment of Therapy After Acute ST-Segment Elevation Myocardial Infarction (Patient Subgroup: Thrombolytic therapy without catheterization)** **Class I** Detection of inducible ischemia and myocardium at risk *(Level of Evidence: B)*

		STEMI (p. e136) **Exercise Myocardial Perfusion Imaging** **Class I** Dipyridamole or adenosine stress perfusion nuclear scintigraphy or dobutamine echocardiography before or early after discharge should be used in patients with STEMI who are not undergoing cardiac catheterization to look for inducible ischemia in patients judged to be unable to exercise. *(Level of Evidence: B)*
50.	**STEMI** ▪ **Hemodynamically stable, no recurrent chest pain symptoms or no signs of HF** ▪ **To evaluate for inducible ischemia** ▪ **No prior coronary angiography**	***RNI (p. 8, Table 3)*** **Recommendations for Use of Radionuclide Testing in Diagnosis, Risk Assessment, Prognosis, and Assessment of Therapy After Acute ST-Segment Elevation Myocardial Infarction (Patient Subgroup: Thrombolytic therapy without catheterization)** **Class I** Detection of inducible ischemia and myocardium at risk *(Level of Evidence: B)* ***STEMI (p. e136)*** **Exercise Myocardial Perfusion Imaging** **Class I** Dipyridamole or adenosine stress perfusion nuclear scintigraphy or dobutamine echocardiography before or early after discharge should be used in patients with STEMI who are not undergoing cardiac catheterization to look for inducible ischemia in patients judged to be unable to exercise. *(Level of Evidence: B)*
51.	**STEMI** ▪ **Hemodynamically unstable, signs of cardiogenic shock, or mechanical complications**	**None**
	UA/NSTEMI	
52.	**UA/NSTEMI** ▪ **Hemodynamically Stable, No Recurrent Chest Pain Symptoms, or No Signs of HF** ▪ **To evaluate for inducible ischemia**	***UA/NSTEMI (p. e28)*** **Risk Stratification Recommendations** **Class I** ▪ Noninvasive stress testing is recommended in low and intermediate-risk patients who have been free of ischemia at rest or with low-level activity and of heart failure for a minimum of 12 to 24 h. *(Level of Evidence: C)* ▪ An imaging modality should be added in patients with resting ST-segment depression (greater

	▪ **No prior coronary angiography**	than or equal to 0.10 mV), LV hypertrophy, bundle-branch block, intraventricular conduction defect, pre-excitation, or digoxin who are able to exercise. In patients undergoing a low-level exercise test, an imaging modality can add sensitivity. *(Level of Evidence: B)* ▪ Pharmacological stress testing with imaging is recommended when physical limitations (e.g., arthritis, amputation, severe peripheral vascular disease, severe chronic obstructive pulmonary disease, general debility) preclude adequate exercise stress. *(Level of Evidence: B)* ▪ A noninvasive test (echocardiogram or radionuclide angiogram) is recommended to evaluate LV function in patients with definite ACS who are not scheduled for coronary angiography and left ventriculography.*(Level of Evidence: B)* **Immediate Management (p. e11)** **Class I** In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow up 12-lead ECG and biomarker measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative stress diagnostic test can be managed as outpatients. (Level of Evidence: C) Patients with possible ACS and negative cardiac biomarkers who are unable to exercise or who have an abnormal resting ECG should undergo a pharmacological stress test. *(Level of Evidence:B)*
ACS—Asymptomatic Post Revascularization (PCI or CABG)		
53.	**ACS – Asymptomatic Post Revascularization (PCI or CABG)** ▪ Timeframe: **Evaluation prior to hospital discharge**	***UA/NSTEMI (p. e11)*** **Immediate Management** **Class I** In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow up 12-lead ECG and biomarker measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative stress diagnostic test can be managed as outpatients. (Level of Evidence: C) Patients with possible ACS and negative cardiac biomarkers who are unable to exercise or who have an abnormal resting ECG should undergo a pharmacological stress test. *(Level of Evidence: B)*

Cardiac Rehabilitation	
54. **ACS – Asymptomatic Post Revascularization (PCI or CABG)** ▪ Timeframe: **Prior to initiation of cardiac rehabilitation (as a stand-alone indication)**	**None**

Table 6. Risk Assessment: Post-Revascularization (PCI or CABG)

Indication	**Guideline Recommendations**
Symptomatic	

55. **Symptomatic** ▪ **Evaluation of Ischemic Equivalent**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class I** Repeat exercise MPI after initial perfusion imaging in patients whose symptoms have changed to redefine the risk for cardiac event. *(Level of Evidence: C)* **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise** **Class I** Adenosine or dipyridamole myocardial perfusion SPECT after initial perfusion imaging in patients whose symptoms have changed to redefine the risk for cardiac event. (*Level of Evidence: C)* ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class I** Exercise myocardial perfusion imaging or exercise echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)* ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class I** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)*
Asymptomatic	

56. **Asymptomatic** ▪ Context: **Incomplete Revascularization** **Additional revascularization feasible**	***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class I** Exercise myocardial perfusion imaging or exercise echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)* ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class I** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)*

57. **Asymptomatic** ▪ Timeframe: **Less than 5 years after CABG**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIa** Exercise myocardial perfusion SPECT at 3 to 5 years after revascularization (either PCI or CABG) in selected, high-risk asymptomatic patients. (*Level of Evidence: B*) **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise** **Class IIa** Adenosine or dipyridamole SPECT at 3 to 5 years after revascularization (either PCI or CABG) in selected, high-risk asymptomatic patients. (*Level of Evidence: B*) ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class I** Exercise myocardial perfusion imaging or exercise echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)* ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class I** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)*

58. **Asymptomatic** ▪ Timeframe: **Greater than or equal to 5 years after CABG**	***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIa** Exercise myocardial perfusion SPECT at 3 to 5 years after revascularization (either PCI or CABG) in selected, high-risk asymptomatic patients. (*Level of Evidence: B*) **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise** **Class IIa** Adenosine or dipyridamole SPECT at 3 to 5 years after revascularization (either PCI or CABG) in selected, high-risk asymptomatic patients. (*Level of Evidence: B*) ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class I** Exercise myocardial perfusion imaging or exercise echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)* ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class I** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)*

59. **Asymptomatic** ▪ Timeframe: **Less than 2 years after PCI**	***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class I** Exercise myocardial perfusion imaging or exercise echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)* ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class I** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)*

60. **Asymptomatic** ▪ Timeframe: **Greater than or equal to 2 years after PCI**	***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Able to Exercise** **Class I** Exercise myocardial perfusion imaging or exercise echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)* ***Stable Angina (p. 22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Diagnosis in Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class I** Adenosine or dipyridamole stress myocardial perfusion imaging or dobutamine echocardiography in patients with prior revascularization (either PCI or CABG). *(Level of Evidence: B)* ***RNI (p. 26)*** **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Able to Exercise (to at least 85% of MPHR)** **Class IIa** Exercise myocardial perfusion SPECT at 3 to 5 years after revascularization (either PCI or CABG) in selected, high-risk asymptomatic patients. (*Level of Evidence: B*) **Recommendations for Diagnosis of Patients With an Intermediate Likelihood of CAD and/or Risk Stratification of Patients With an Intermediate or High Likelihood of CAD Who Are Unable to Exercise** **Class IIa** Adenosine or dipyridamole SPECT at 3 to 5 years after revascularization (either PCI or CABG) in selected, high-risk asymptomatic patients. (*Level of Evidence: B*)
Cardiac Rehabilitation	
61. **Cardiac Rehabilitation** ▪ Timeframe: **Prior to initiation of cardiac rehabilitation (as a stand-alone indication)**	**None**

Table 7. Assessment of Viability/Ischemia

Indication	Guideline Recommendations
Ischemic Cardiomyopathy/Assessment of Viability	

62.	**Ischemic Cardiomyopathy/Assessment of Viability** ▪ Test Results: **Known severe LV dysfunction** ▪ Context: **Patient eligible for revascularization**	***RNI (p. 27)*** **Recommendations for the Use of Radionuclide Imaging in Patients With Heart Failure: Fundamental Assessment** **Class I** Assessment of myocardial viability for consideration of revascularization in patients with CAD and LV systolic dysfunction who do not have angina (Level of Evidence: B) ***Heart Failure (p. 9)*** **Recommendations for the Initial Clinical Assessment of Patients Presenting with HF** **Class IIa** Noninvasive imaging to detect myocardial ischemia and viability is reasonable in patients presenting with HF who have known coronary artery disease and no angina, unless the patient is not eligible for revascularization of any kind. (Level of Evidence: C) ***Stable Angina (p.22)*** **Recommendations for Cardiac Stress Imaging as the Initial Test for Risk Stratification of Patients With Chronic Stable Angina Who Are Unable to Exercise** **Class I** Dipyridamole or adenosine myocardial perfusion imaging or dobutamine echocardiography to assess the functional significance of coronary lesions (if not already known) in planning PCI. (Level of Evidence: B) ***Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death*** **Left Ventricular Function and Imaging (p. e15)** **Class I** ET with an imaging modality (echocardiography or nuclear perfusion [single-photon emission computed tomography (SPECT)]) is recommended to detect silent ischemia in patients with VA who have an intermediate probability of having CHD by age, symptoms, and gender, and in whom ECG assessment is less reliable because of digoxin use, left ventricular (LV) hypertrophy, greater than 1 mm ST-segment depression at rest, Wolff-Parkinson-White Syndrome or left bundle-branch block. (Level of Evidence: B) Pharmacological stress testing with an imaging modality (echocardiography or myocardial perfusion SPECT) is recommended to detect silent ischemia in patients with VA who have an intermediate probability of having CHD by age, symptoms, and gender and are physically unable to perform a symptom-limited exercise test. (Level of Evidence: B)

Table 8. Evaluation of Ventricular Function

Indication	Guideline Recommendations
Evaluation of Left Ventricular Function	

63. **Evaluation of Left Ventricular Function** ▪ Test Results: **Assessment of LV function with radionuclide angiography (ERNA or FP (first pass) RNA)** ▪ **In absence of recent reliable diagnostic information regarding ventricular function obtained with another imaging modality**	***RNI (p. 27)*** **Recommendations for the Use of Radionuclide Imaging in Patients With Heart Failure: Fundamental Assessment** **Class I** Initial assessment of LV and RV function at rest* *(Level of Evidence: A)* *National consensus treatment guidelines are directed by quantitative assessment of LVEF and identification of LVEF less than or equal to 40% (356). ***Heart Failure (p. 9)*** **Recommendations for the Initial Clinical Assessment of Patients Presenting with HF** **Class II** Two-dimensional echocardiography with Doppler should be performed during initial evaluation of patients presenting with HF to assess LVEF, LV size, wall thickness, and valve function. Radionuclide ventriculography can be performed to assess LVEF and volume. (Level of Evidence: C) **Recommendations for Diagnosis and Initial Evaluation (pg. e32)** **Class I** Radionuclide angiography or magnetic resonance imaging is indicated for the initial and serial assessment of LV volume and function at rest in patients with AR and suboptimal echocardiograms. *(Level of Evidence: B)* **Class IIb** Exercise stress testing in patients with radionuclide angiography may be considered for assessment of LV function in asymptomatic or symptomatic patients with chronic AR. *(Level of Evidence: B)* ***UA/NSTEMI (p. e28)*** **Risk Stratification** **Class I** A noninvasive test (echocardiogram or radionuclide angiogram) is recommended to evaluate LV function in patients with definite ACS who are not scheduled for coronary angiography and left ventriculography.*(Level of Evidence: B)* ***Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death*** **Left Ventricular Function and Imaging (p. e15)** **Class IIa** Magnetic resonance imaging, cardiac computed tomography, or radionuclide angiography can be useful in patients with VA when echocardiography does not provide accurate assessment of LV and RV function, and/or evaluation of structural changes. (Level of Evidence: B)

64. **Evaluation of Left Ventricular Function** ▪ Context: **Routine+ use of rest/stress ECG-gating with SPECT or PET myocardial perfusion imaging**	***Heart Failure (p. 9)*** **Recommendations for Diagnosis and Initial Evaluation (pg. e32)** **Class I** Radionuclide angiography or magnetic resonance imaging is indicated for the initial and serial assessment of LV volume and function at rest in patients with AR and suboptimal echocardiograms. *(Level of Evidence: B)* **Class IIb** Exercise stress testing in patients with radionuclide angiography may be considered for assessment of LV function in asymptomatic or symptomatic patients with chronic AR. *(Level of Evidence: B)* ***UA/NSTEMI (p. e28)*** **Risk Stratification** **Class I** A noninvasive test (echocardiogram or radionuclide angiogram) is recommended to evaluate LV function in patients with definite ACS who are not scheduled for coronary angiography and left ventriculography.*(Level of Evidence: B)* ***Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death*** **Left Ventricular Function and Imaging (p. e15)** **Class IIa** Magnetic resonance imaging, cardiac computed tomography, or radionuclide angiography can be useful in patients with VA when echocardiography does not provide accurate assessment of LV and RV function, and/or evaluation of structural changes. (Level of Evidence: B)

65. **Evaluation of Left Ventricular Function** Context: **Routine use of FP RNA in conjunction with rest/stress gated SPECT MPI** **Detection of multi-vessel CAD**	***Heart Failure (p. 9)*** **Recommendations for Diagnosis and Initial Evaluation (pg. e32)** **Class I** Radionuclide angiography or magnetic resonance imaging is indicated for the initial and serial assessment of LV volume and function at rest in patients with AR and suboptimal echocardiograms. *(Level of Evidence: B)* **Class IIb** Exercise stress testing in patients with radionuclide angiography may be considered for assessment of LV function in asymptomatic or symptomatic patients with chronic AR. *(Level of Evidence: B)* ***UA/NSTEMI (p. e28)*** **Risk Stratification** **Class I** A noninvasive test (echocardiogram or radionuclide angiogram) is recommended to evaluate LV function in patients with definite ACS who are not scheduled for coronary angiography and left ventriculography.*(Level of Evidence: B)* ***Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death*** **Left Ventricular Function and Imaging (p. e15)** **Class IIa** Magnetic resonance imaging, cardiac computed tomography, or radionuclide angiography can be useful in patients with VA when echocardiography does not provide accurate assessment of LV and RV function, and/or evaluation of structural changes. (Level of Evidence: B)

66. **Evaluation of Left Ventricular Function** Context: **Selective use of FP RNA in conjunction with rest/stress gated SPECT MPI** **Borderline, mild, or moderate stenoses in three vessels OR moderate or equivocal left main stenosis in left dominant system**	***Heart Failure (p. 9)*** **Recommendations for Diagnosis and Initial Evaluation (pg. e32)** **Class I** Radionuclide angiography or magnetic resonance imaging is indicated for the initial and serial assessment of LV volume and function at rest in patients with AR and suboptimal echocardiograms. *(Level of Evidence: B)* **Class IIb** Exercise stress testing in patients with radionuclide angiography may be considered for assessment of LV function in asymptomatic or symptomatic patients with chronic AR. *(Level of Evidence: B)* ***UA/NSTEMI (p. e28)*** **Risk Stratification** **Class I** A noninvasive test (echocardiogram or radionuclide angiogram) is recommended to evaluate LV function in patients with definite ACS who are not scheduled for coronary angiography and left ventriculography.*(Level of Evidence: B)* ***Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death*** **Left Ventricular Function and Imaging (p. e15)** **Class IIa** Magnetic resonance imaging, cardiac computed tomography, or radionuclide angiography can be useful in patients with VA when echocardiography does not provide accurate assessment of LV and RV function, and/or evaluation of structural changes. (Level of Evidence: B)
Use of Potentially Cardiotoxic Therapy (e.g. Doxorubicin)	

67.	**Use of Potentially Cardiotoxic Therapy (e.g., doxorubicin)** ▪ Context: **Serial assessment of LV function with radionuclide angiography (ERNA or FP RNA)** **Baseline and serial measures after key therapeutic milestones or evidence of toxicity**	***Heart Failure (p. 16)*** **Recommendations for Patients at High Risk for Developing Heart Failure (Stage A)** **Class I** Healthcare providers should perform a noninvasive evaluation of LV function (i.e., LVEF) in patients with a strong family history of cardiomyopathy or in those receiving cardiotoxic intervention. (*Level of Evidence: C)* ***RNI (p. 34)*** **Recommendations for the Use of Radionuclide Imaging to Diagnose Specific Causes of Dilated Cardiomyopathy** **Class I** Rest RNA – Baseline and serial monitoring of LV function during therapy with cardiotoxic drugs (e.g., doxorubicin). (Level of Evidence: A) ***Chronic Heart Failure in the Adult (pg. e16)*** **Recommendations for Patients At High Risk for Developing HF** **Class I** Healthcare providers should perform a noninvasive evaluation of LV function (i.e., LVEF) in patients with a strong family history of cardiomyopathy or in those receiving cardiotoxic interventions. (Level of Evidence: C)