Journal of the American College of Cardiology
Vol. xx, No. x, 2007
ISSN 0735-1097/07/$32.00
doi:10.1016/j.jacc.2007.05.003
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Published by Elsevier Inc.

ACCF/ASE/ACEP/ASNC/SCAI/SCCT/SCMR 2007 Appropriateness Criteria for Transthoracic and Transesophageal Echocardiography*

A Report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group, American Society of Echocardiography, American College of Emergency Physicians, American Society of Nuclear Cardiology, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and the Society for Cardiovascular Magnetic Resonance

Endorsed by the American College of Chest Physicians and the Society of Critical Care Medicine

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This document was approved by the American College of Cardiology Board of Trustees in May 2007. When citing this document, the American College of Cardiology would appreciate the following citation format: Douglas PS, Khandheria B, Stainback RF, Weissman NJ. ACCF/ASE/ACEP/ASNC/SCAI/SCCT/SCMR 2007 appropriateness criteria for transthoracic and transesophageal echocardiography. J Am Coll Cardiol 2007;xx:xxxx–xxxx.

This article has been copublished in the *Journal of the American Society of Echocardiography*.

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Abstract

The American College of Cardiology Foundation (ACCF) and the American Society of Echocardiography (ASE), together with key specialty and subspecialty societies, conducted an appropriateness review for transthoracic and transesophageal echocardiography (TTE/TEE). This review assesses the risks and benefits of TTE and/or TEE for several indications or clinical scenarios and scored them based on a scale of 1 to 9. The upper range (7 to 9) implies that the test is generally acceptable and is a reasonable approach, and the lower range (1 to 3) implies that the test is generally not acceptable and is not a reasonable approach. The midrange (4 to 6) indicates a clinical scenario for which the indication for an echocardiogram is uncertain.

The indications for this review were drawn from common applications or anticipated uses as well as current clinical practice guidelines. Use of TTE/TEE for initial evaluation of structure and function was viewed favorably, while routine repeat testing and general screening uses in certain clinical scenarios were viewed less favorably. It is anticipated that these results will have a significant impact on physician

decision-making and performance, 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 American College of Cardiology Foundation (ACCF) has undertaken a process to determine the appropriateness of cardiovascular imaging for selected patient indications.

Appropriateness criteria publications reflect an ongoing effort by the College 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 the 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 classification system of the International Classification of Diseases, ninth revision (ICD-9).

The ACCF believes that a 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 appropriateness criteria is to improve patient care and health outcomes in a cost-effective manner but is not intended to ignore the acknowledged 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. Thus, appropriateness criteria should not be considered substitutes for sound clinical judgment and practice experience.

Each Appropriateness Criteria Technical Panel is asked to assess whether the use of the test for each indication is appropriate, uncertain, or inappropriate; and the following definition of appropriateness is provided:

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

The Technical Panel scores each indication as follows:

Score 7 to 9

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

Score 4 to 6

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

Score 1 to 3

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

The intermediate category has been discussed at length by the Working Group. The contributors to this document development process acknowledge the diversity in clinical opinion for particular patient presentations. The consensus of the Working Group is that this intermediate level of appropriateness should be labeled "uncertain," as critical patient or research data are lacking and/or significant differences of opinion exist among panel members regarding the value of the method for that particular indication. It is anticipated that the appropriateness criteria reports will require frequent 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 deliberately included less than 50% representation by specialists in the particular procedure under evaluation. Such specialists, while offering important clinical and technical insights into the use of the procedure, 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.

It is with gratitude that we applaud the Technical Panel, a professional group with a wide range of skills and insights, for a thoughtful and thorough deliberation of the merits of TTE/TEE 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 Robert Bonow, MD, Roberto Lang, MD, and Alan Pearlman, MD, for reviewing the draft indications; to Peggy Christiansen, the ACC librarian, for her comprehensive literature searches; to Karen Caruth, who continually drove the process forward; and to ACCF Past President Pamela S. Douglas, MD, MACC, for her insight and leadership.

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Introduction

This report addresses the appropriateness of transthoracic and transesophageal echocardiography (TTE/TEE). The test characteristics of TTE and TEE have long been recognized as beneficial for defining cardiac structure and function. The relative ease of use and low risk of TTE/TEE compared to other cardiovascular imaging techniques provide many advantages, but also create opportunities for

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

overuse and misuse in patients who may not obtain a benefit, or who could have achieved a similar benefit without the addition of the test. In particular, inappropriate use may be costly and may prompt potentially harmful and costly downstream testing and treatment such as unwarranted coronary revascularization or unnecessary repeat follow-up. Concerns about inappropriate use exist among those who pay for these services and clinical leaders who evaluate the effectiveness of testing.

Methods

The range of potential indications for echocardiography is large. Thus, the indications included in this review are purposefully broad, and comprise a wide array of cardiovascular signs and symptoms as well as clinical judgment as to the likelihood of cardiovascular abnormalities.

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 titled, "ACCF Proposed Method for Evaluating the Appropriateness of Cardiovascular Imaging" (1). Briefly, this process combines evidence-based medicine and practice experience by engaging a Technical Panel in a modified Delphi exercise.

General Assumptions for TTE/TEE

To prevent any nuances of interpretation, all indications were considered with the following important assumptions:

1. All indications are assumed to be for adult patients (18 years of age or older).
2. The test is performed and interpreted by a qualified individual in a facility that is proficient in the imaging technique (2–5).

The indications were constructed by echocardiography experts and modified based on discussions among the Working Group, and feedback from independent reviewers and the Technical Panel. Wherever possible, indications were mapped to relevant clinical guidelines and key publications/references (Online Appendix B at http://www.acc.org).

The Technical Panel was comprised of clinician experts, some with backgrounds in cardiac imaging and others with impeccable credentials in general cardiovascular medicine, cardiac surgery, emergency medicine, health services research, and health plan administration.*

Abbreviations

APC = atrial premature contraction
AS = aortic stenosis
ASD = atrial septal defect
BNP = B-type natriuretic peptide
COPD = chronic obstructive pulmonary disease
CRT = cardiac resynchronization therapy
CT = computed tomography
ECG = electrocardiogram
LV = left ventricular
MI = myocardial infarction
MR = mitral regurgitation
MRI = magnetic resonance imaging
MS = mitral stenosis
PDA = patent ductus arteriosus
PFO = patent foramen ovale
PVC = premature ventricular contraction
SPECT = single-photon emission computed tomography
SVT = supraventricular tachycardia
TIA = transient ischemic attack
VSD = ventricular septal defect
VT = ventricular tachycardia

*Full details about the backgrounds of the members of the Technical Panel can be found in Appendix C.

TTE/TEE Assumptions

Similar to the general assumptions listed previously, panelists were asked to consider several assumptions specifically for TTE/TEE, including:

1. Panel members are to assume that a TTE examination and report will include:
   a. Use of a standard set of 2-dimensional views evaluating the cardiac structures (6,7).
   b. Use of 2-dimensional/M-mode imaging, color flow Doppler, and spectral Doppler as they are generally considered to be important elements of a comprehensive TTE or TEE study (8–10). In evaluating the appropriate indications, it is assumed that these elements would be part of the performance of the comprehensive TTE or TEE examination.
   c. Use of contrast is indicated and will be performed when more than 2 contiguous segments of the left ventricular endocardial border are not visualized (11).
2. In general, it is assumed that TEE is appropriately used as an adjunct or subsequent test to TTE when suboptimal TTE images preclude obtaining a diagnostic study. The indications for which TEE may reasonably be the test of first choice include, but are not limited to, the indications presented in Table 7 of this document.
3. In addition, it is reasonable to use TEE as a first test when:
   a. It is likely that suboptimal images will preclude obtaining a diagnostic TTE study based on patient characteristics alone (patient is intubated, recent postoperative, intraprocedural study, severe chest wall abnormalities, COPD, etc.); or when
   b. visualization of certain structures seen best by TEE is necessary to achieve the goals of the imaging test

including, but not limited to, evaluation of the mitral valve, atria, great vessels, and/or prosthetic valves.

4. Intraoperative echocardiography is an important use of this imaging modality. However, we explicitly did not consider indications for its use as this is outside the scope of this document.
5. The range of potential indications for TTE/TEE is quite large, particularly in comparison with other cardiovascular imaging tests. Thus, the indications are, at times, purposefully broad to cover an array of cardiovascular signs and symptoms as well as the ordering physician's best judgment as to the presence of cardiovascular abnormalities. Additionally, there are likely clinical scenarios that are not covered by the current indications.

Results of Ratings

The final ratings for TTE and TEE (Tables 1 to 7) are listed sequentially as obtained from the second-round rating sheets submitted by each panelist. Additionally, the indications are presented by appropriateness category (Tables 8 to 10). As required by ACCF appropriateness methodology (1), these ratings are adopted as is, without modification by the indication Writing Group or Working Group.

Definitions used by the Technical Panel can be found in Appendix A. Supplemental tables, including documentation of the mean absolute deviation from the median and level of agreement of rankings for each indication, can be found in the Online Appendix A at http://www.acc.org.

For the 59 indications for TTE/TEE, 44 were found to be appropriate, and 1 was uncertain. Fourteen of the indications were felt to be inappropriate reasons for the performance of a TTE/TEE study. The level of agreement among panelists as defined by RAND (12) was analyzed based on the BIOMED rule for a panel of 14 to 16. As such, agreement was defined as an indication where 4 or fewer panelists rated outside the 3-point region containing the median. Disagreement was defined as where the number of panelists rating in each extreme region was at least 5. For the indications labeled as appropriate, the panel showed 100% agreement, and for the indications labeled inappropriate, the panel was in agreement 78.6% of the time. Disagreement was not found for any of the indications.

TTE/TEE is a well-established test with many applicable indications. Two areas where TTE/TEE tests were generally considered reasonable were when conducting an initial evaluation of cardiac structure and ventricular function or the initial evaluation of suspected valvular dysfunction. The majority of inappropriate indications were for indications that suggested annual testing.

TTE/TEE Appropriateness Criteria (by Indication)

Table 1. General Evaluation of Structure and Function

Indication		Appropriateness Score (1–9)
	Suspected Cardiac Etiology—General	
1.	Symptoms potentially due to suspected cardiac etiology, including but not limited to dyspnea, shortness of breath, lightheadedness, syncope, TIA, cerebrovascular events	A (9)
2.	Prior testing that is concerning for heart disease (i.e., chest X-ray, baseline scout images for stress echocardiogram, ECG, elevation of serum BNP)	A (8)
	Adult Congenital Heart Disease	
3.	Assessment of known or suspected adult congenital heart disease including anomalies of great vessels and cardiac chambers and valves or suspected intracardiac shunt (ASD, VSD, PDA) either in unoperated patients or following repair/operation	A (9)
4.	Routine (yearly) evaluation of asymptomatic patients with corrected ASD, VSD, or PDA more than 1 year after successful correction	I (3)
	Arrhythmias	
5.	Patients who have isolated APC or PVC without other evidence of heart disease	I (2)
6.	Patients who have sustained or nonsustained SVT or VT	A (8)
	LV Function Evaluation	
7.	Evaluation of LV function with prior ventricular function evaluation within the past year with normal function (such as prior echocardiogram, LV gram, SPECT, cardiac MRI) in patients in whom there has been no change in clinical status	I (2)
8.	Initial evaluation of LV function following acute MI	A (9)
9.	Re-evaluation of LV function following MI during recovery phase when results will guide therapy	A (8)
	Pulmonary Hypertension	
10.	Evaluation of known or suspected pulmonary hypertension including evaluation of right ventricular function and estimated pulmonary artery pressure	A (8)

Table 2. Cardiovascular Evaluation in an Acute Setting

Indication		Appropriateness Score (1–9)
Hypotension or Hemodynamic Instability		
11.	Evaluation of hypotension or hemodynamic instability of uncertain or suspected cardiac etiology	A (9)
Myocardial Ischemia/Infarction		
12.	Evaluation of acute chest pain with suspected myocardial ischemia in patients with nondiagnostic laboratory markers and ECG and in whom a resting echocardiogram can be performed during pain	A (8)
13.	Evaluation of suspected complication of myocardial ischemia/infarction, including but not limited to acute MR, hypoxemia, abnormal chest X-ray, VSD, free-wall rupture/tamponade, shock, right ventricular involvement, heart failure, or thrombus	A (9)
Respiratory Failure		
14.	Evaluation of respiratory failure with suspected cardiac etiology	A (8)
Pulmonary Embolism		
15.	Initial evaluation of patient with suspected pulmonary embolism in order to establish diagnosis	I (3)
16.	Evaluation of patient with known or suspected acute pulmonary embolism to guide therapy (i.e., thrombectomy and thrombolytics)	A (8)

Table 3. Evaluation of Valvular Function

Indication		Appropriateness Score (1–9)
Murmur		
17.	Initial evaluation of murmur in patients for whom there is a reasonable suspicion of valvular or structural heart disease	A (9)
Mitral Valve Prolapse		
18.	Initial evaluation of patient with suspected mitral valve prolapse	A (9)
19.	Routine (yearly) re-evaluation of mitral valve prolapse in patients with no or mild mitral regurgitation and no change in clinical status	I (2)
Native Valvular Stenosis		
20.	Initial evaluation of known or suspected native valvular stenosis	A (9)
21.	Routine (yearly) re-evaluation of an asymptomatic patient with mild native AS or mild-moderate native MS and no change in clinical status	I (2)
22.	Routine (yearly) evaluation of an asymptomatic patient with severe native valvular stenosis	A (7)
23.	Re-evaluation of a patient with native valvular stenosis who has had a change in clinical status	A (9)
Native Valvular Regurgitation		
24.	Initial evaluation of known or suspected native valvular regurgitation	A (9)
25.	Routine (yearly) re-evaluation of native valvular regurgitation in an asymptomatic patient with mild regurgitation, no change in clinical status, and normal LV size	I (2)
26.	Routine (yearly) re-evaluation of an asymptomatic patient with severe native valvular regurgitation with no change in clinical status	A (8)
27.	Re-evaluation of native valvular regurgitation in patients with a change in clinical status	A (9)
Prosthetic Valve		
28.	Initial evaluation of prosthetic valve for establishment of baseline after placement	A (9)
29.	Routine (yearly) evaluation of a patient with a prosthetic valve in whom there is no suspicion of valvular dysfunction and no change in clinical status	I (3)
30.	Re-evaluation of patients with prosthetic valve with suspected dysfunction or thrombosis *or* a change in clinical status	A (9)
Infective Endocarditis (Native or Prosthetic Valves)		
31.	Initial evaluation of suspected infective endocarditis (native and/or prosthetic valve) with positive blood cultures or a new murmur	A (9)
32.	Evaluation of native and/or prosthetic valves in patients with transient fever but without evidence of bacteremia or new murmur	I (2)
33.	Re-evaluation of infective endocarditis in patients with any of the following: virulent organism, severe hemodynamic lesion, aortic involvement, persistent bacteremia, a change in clinical status, or symptomatic deterioration	A (9)

Table 4. Evaluation of Intracardiac and Extracardiac Structures and Chambers

Indication		Appropriateness Score (1–9)
34.	Evaluation for cardiovascular source of embolic event (PFO/ASD, thrombus, neoplasm)	A (8)
35.	Evaluation of cardiac mass (suspected tumor or thrombus)	A (9)
36.	Evaluation of pericardial conditions including but not limited to pericardial mass, effusion, constrictive pericarditis, effusive-constrictive conditions, patients post-cardiac surgery, or suspected pericardial tamponade	A (9)

Table 5. Evaluation of Aortic Disease

Indication		Appropriateness Score (1–9)
37.	Known or suspected Marfan disease for evaluation of proximal aortic root and/or mitral valve	A (9)

Table 6. Evaluation of Hypertension, Heart Failure, or Cardiomyopathy

Indication		Appropriateness Score (1–9)
	Hypertension	
38.	Initial evaluation of suspected hypertensive heart disease	A (8)
39.	Routine evaluation of patients with systemic hypertension without suspected hypertensive heart disease	I (3)
40.	Re-evaluation of a patient with known hypertensive heart disease without a change in clinical status	I (3)
	Heart Failure	
41.	Initial evaluation of known or suspected heart failure (systolic or diastolic)	A (9)
42.	Routine (yearly) re-evaluation of patients with heart failure (systolic or diastolic) in whom there is no change in clinical status	I (3)
43.	Re-evaluation of known heart failure (systolic or diastolic) to guide therapy in a patient with a change in clinical status	A (9)
	Pacing Device Evaluation	
44.	Evaluation for dyssynchrony in a patient being considered for CRT	A (8)
45.	Patient with known implanted pacing device with symptoms possibly due to suboptimal pacing device settings to re-evaluate for dyssynchrony and/or revision of pacing device settings	A (8)
	Hypertrophic Cardiomyopathy	
46.	Initial evaluation of known or suspected hypertrophic cardiomyopathy	A (9)
47.	Routine (yearly) evaluation of hypertrophic cardiomyopathy in a patient with no change in clinical status	I (3)
48.	Re-evaluation of known hypertrophic cardiomyopathy in a patient with a change in clinical status to guide or evaluate therapy	A (9)
	Cardiomyopathy (Other)	
49.	Evaluation of suspected restrictive, infiltrative, or genetic cardiomyopathy	A (9)
50.	Screening study for structure and function in first-degree relatives of patients with inherited cardiomyopathy	A (8)
	Therapy With Cardiotoxic Agents	
51.	Baseline and serial re-evaluations in patients undergoing therapy with cardiotoxic agents	A (8)

Table 7. Use of Transesophageal Echocardiogram (TEE)

Indication		Appropriateness Score (1–9)
Use of TEE as Initial Test*—Common Uses		
52.	Evaluation of suspected acute aortic pathology including dissection/transsection	A (9)
53.	Guidance during percutaneous noncoronary cardiac interventions including but not limited to septal ablation in patients with hypertrophic cardiomyopathy, mitral valvuloplasty, PFO/ASD closure, radiofrequency ablation	A (9)
54.	To determine mechanism of regurgitation and determine suitability of valve repair	A (9)
55.	To diagnose/manage endocarditis with a moderate or high pre-test probability (e.g., bacteremia, especially staph bacteremia or fungemia)	A (9)
56.	Persistent fever in patient with intracardiac device	A (9)
Use of TEE as the Initial Test*—Common Uses—Atrial Fibrillation/Flutter		
57.	Evaluation of patient with atrial fibrillation/flutter to facilitate clinical decision-making with regards to anticoagulation and/or cardioversion and/or radiofrequency ablation	A (9)
58.	Evaluation of patient with atrial fibrillation/flutter for left atrial thrombus or spontaneous contrast when a decision has been made to anticoagulate and not to perform cardioversion	I (3)
Use of TEE—Embolic Event		
59.	Evaluation for cardiovascular source of embolic event in a patient who has a normal TTE and normal ECG and no history of atrial fibrillation/flutter	U (6)

*In general, it is assumed that TEE is appropriately used as an adjunct or subsequent test to TTE when suboptimal TTE images preclude obtaining a diagnostic study. The indications for which TEE may reasonably be the test of first choice include, but are not limited to, the indications presented in the TEE table.

TTE/TEE Appropriateness Criteria (by Appropriateness Category)

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

Indication		Appropriateness Score (1–9)
General Evaluation of Structure and Function—Suspected Cardiac Etiology—General		
1.	Symptoms potentially due to suspected cardiac etiology, including but not limited to dyspnea, shortness of breath, lightheadedness, syncope, TIA, cerebrovascular events	A (9)
2.	Prior testing that is concerning for heart disease (i.e., chest X-ray, baseline scout images for stress echocardiogram, ECG, elevation of serum BNP)	A (8)
General Evaluation of Structure and Function—Adult Congenital Heart Disease		
3.	Assessment of known or suspected adult congenital heart disease including anomalies of great vessels and cardiac chambers and valves, or suspected intracardiac shunt (ASD, VSD, PDA) either in unoperated patient or following repair/operation	A (9)
General Evaluation of Structure and Function—Arrhythmias		
6.	Patients who have sustained or nonsustained SVT or VT	A (8)
General Evaluation of Structure and Function—LV Function Evaluation		
8.	Initial evaluation of LV function following acute MI	A (9)
9.	Re-evaluation of LV function following MI during recovery phase when results will guide therapy	A (8)
General Evaluation of Structure and Function—Pulmonary Hypertension		
10.	Evaluation of known or suspected pulmonary hypertension including evaluation of right ventricular function and estimated pulmonary artery pressure	A (8)
Cardiovascular Evaluation in an Acute Setting—Hypotension or Hemodynamic Instability		
11.	Evaluation of hypotension or hemodynamic instability of uncertain or suspected cardiac etiology	A (9)
Cardiovascular Evaluation in an Acute Setting—Myocardial Ischemia/Infarction		
12.	Evaluation of acute chest pain with suspected myocardial ischemia in patients with nondiagnostic laboratory markers and ECG and in whom a resting echocardiogram can be performed during pain	A (8)
13.	Evaluation of suspected complication of myocardial ischemia/infarction, including but not limited to acute mitral regurgitation, hypoxemia, abnormal chest X-ray, VSD, free-wall rupture/tamponade, shock, right ventricular involvement, heart failure, or thrombus	A (9)
Cardiovascular Evaluation in an Acute Setting—Respiratory Failure		
14.	Evaluation of respiratory failure with suspected cardiac etiology	A (8)
Cardiovascular Evaluation in an Acute Setting—Pulmonary Embolism		
16.	Evaluation of patient with known or suspected acute pulmonary embolism to guide therapy (i.e., thrombectomy and thrombolytics)	A (8)

Table 8. Continued

Indication		Appropriateness Score (1–9)
Evaluation of Valvular Function—Murmur		
17.	Initial evaluation of murmur in patients for whom there is a reasonable suspicion of valvular or structural heart disease	A (9)
Evaluation of Valvular Function—Mitral Valve Prolapse		
18.	Initial evaluation of patient with suspected mitral valve prolapse	A (9)
Evaluation of Valvular Function—Native Valvular Stenosis		
20.	Initial evaluation of known or suspected native valvular stenosis	A (9)
22.	Routine (yearly) evaluation of an asymptomatic patient with severe native valvular stenosis	A (7)
23.	Re-evaluation of a patient with native valvular stenosis who has had a change in clinical status	A (9)
Evaluation of Valvular Function—Native Valvular Regurgitation		
24.	Initial evaluation of known or suspected native valvular regurgitation	A (9)
26.	Routine (yearly) re-evaluation of an asymptomatic patient with severe native valvular regurgitation with no change in clinical status	A (8)
27.	Re-evaluation of native valvular regurgitation in patients with a change in clinical status	A (9)
Evaluation of Valvular Function—Prosthetic Valve		
28.	Initial evaluation of prosthetic valve for establishment of baseline after placement	A (9)
30.	Re-evaluation of patients with prosthetic valve with suspected dysfunction or thrombosis *or* a change in clinical status	A (9)
Evaluation of Valvular Function—Infective Endocarditis (Native or Prosthetic Valves)		
31.	Initial evaluation of suspected infective endocarditis (native and/or prosthetic valve) with positive blood cultures or a new murmur	A (9)
33.	Re-evaluation of infective endocarditis in patients with any of the following: virulent organism, severe hemodynamic lesion, aortic involvement, persistent bacteremia, a change in clinical status, or symptomatic deterioration	A (9)
Evaluation of Intracardiac and Extracardiac Structures and Chambers		
34.	Evaluation for cardiovascular source of embolic event (PFO/ASD, thrombus, neoplasm)	A (8)
35.	Evaluation of cardiac mass (suspected tumor or thrombus)	A (9)
36.	Evaluation of pericardial conditions including but not limited to pericardial mass, effusion, constrictive pericarditis, effusive-constrictive conditions, patients post-cardiac surgery, or suspected pericardial tamponade	A (9)
Evaluation of Aortic Disease		
37.	Known or suspected Marfan disease for evaluation of proximal aortic root and/or mitral valve	A (9)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Hypertension		
38.	Initial evaluation of suspected hypertensive heart disease	A (8)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Heart Failure		
41.	Initial evaluation of known or suspected heart failure (systolic or diastolic)	A (9)
43.	Re-evaluation of known heart failure (systolic or diastolic) to guide therapy in a patient with a change in clinical status	A (9)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Pacing Device Evaluation		
44.	Evaluation for dyssynchrony in a patient being considered for CRT	A (8)
45.	Patient with known implanted pacing device with symptoms possibly due to suboptimal pacing device settings to re-evaluate for dyssynchrony and/or revision of pacing device settings	A (8)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Hypertrophic Cardiomyopathy		
46.	Initial evaluation of known or suspected hypertrophic cardiomyopathy	A (9)
48.	Re-evaluation of known hypertrophic cardiomyopathy in a patient with a change in clinical status to guide or evaluate therapy	A (9)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Cardiomyopathy (Other)		
49.	Evaluation of suspected restrictive, infiltrative, or genetic cardiomyopathy	A (9)
50.	Screening study for structure and function in first-degree relatives of patients with inherited cardiomyopathy	A (8)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Therapy With Cardiotoxic Agents		
51.	Baseline and serial re-evaluations in patients undergoing therapy with cardiotoxic agents	A (8)
Use of TEE as the Initial Test—Common Uses		
52.	Evaluation of suspected acute aortic pathology including dissection/transsection	A (9)
53.	Guidance during percutaneous noncoronary cardiac interventions including but not limited to septal ablation in patients with hypertrophic cardiomyopathy, mitral valvuloplasty, PFO/ASD closure, radiofrequency ablation	A (9)
54.	To determine mechanism of regurgitation and determine suitability of valve repair	A (9)
55.	To diagnose/manage endocarditis with a moderate or high pre-test probability (e.g., bacteremia, especially staph bacteremia or fungemia)	A (9)
56.	Persistent fever in patient with intracardiac device	A (9)
Use of TEE as the Initial Test—Common Uses—Atrial Fibrillation/Flutter		
57.	Evaluation of patient with atrial fibrillation/flutter to facilitate clinical decision-making with regards to anticoagulation and/or cardioversion and/or radiofrequency ablation	A (9)

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

Indication		Appropriateness Score (1–9)
Use of TEE as the Initial Test—Embolic Event		
59.	Evaluation for cardiovascular source of embolic event in a patient who has a normal TTE and normal ECG and no history of atrial fibrillation/flutter	U (6)

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

Indication		Appropriateness Score (1–9)
General Evaluation of Structure and Function—Adult Congenital Heart Disease		
4.	Routine (yearly) evaluation of asymptomatic patients with corrected ASD, VSD, or PDA more than 1 year after successful correction	I (3)
General Evaluation of Structure and Function—Arrhythmias		
5.	Patients who have isolated APC or PVC without other evidence of heart disease	I (2)
General Evaluation of Structure and Function—LV Function Evaluation		
7.	Evaluation of LV function with prior ventricular function evaluation within the past year with normal function (such as prior echocardiogram, LV gram, SPECT, cardiac MRI) in patients in whom there has been no change in clinical status	I (2)
Cardiovascular Evaluation in an Acute Setting—Pulmonary Embolism		
15.	Initial evaluation of patient with suspected pulmonary embolism in order to establish diagnosis	I (3)
Evaluation of Valvular Function—Mitral Valve Prolapse		
19.	Routine (yearly) re-evaluation of mitral valve prolapse in patients with no or mild MR and no change in clinical status	I (2)
Evaluation of Valvular Function—Native Valvular Stenosis		
21.	Routine (yearly) re-evaluation of an asymptomatic patient with mild native AS or mild-moderate native MS and no change in clinical status	I (2)
Evaluation of Valvular Function—Native Valvular Regurgitation		
25.	Routine (yearly) re-evaluation of native valvular regurgitation in an asymptomatic patient with mild regurgitation, no change in clinical status, and normal LV size	I (2)
Evaluation of Valvular Function—Prosthetic Valve		
29.	Routine (yearly) evaluation of a patient with a prosthetic valve in whom there is no suspicion of valvular dysfunction and no change in clinical status	I (3)
Evaluation of Valvular Function—Infective Endocarditis (Native or Prosthetic Valves)		
32.	Evaluation of native and/or prosthetic valves in patients with transient fever but without evidence of bacteremia or new murmur	I (2)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Hypertension		
39.	Routine evaluation of patients with systemic hypertension without suspected hypertensive heart disease	I (3)
40.	Re-evaluation of a patient with known hypertensive heart disease without a change in clinical status	I (3)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Heart Failure		
42.	Routine (yearly) re-evaluation of patients with heart failure (systolic or diastolic) in whom there is no change in clinical status	I (3)
Evaluation of Hypertension, Heart Failure, or Cardiomyopathy—Hypertrophic Cardiomyopathy		
47.	Routine (yearly) evaluation of hypertrophic cardiomyopathy in a patient with no change in clinical status	I (3)
Use of TEE as the Initial Test—Common Uses—Atrial Fibrillation/Flutter		
58.	Evaluation of a patient with atrial fibrillation/flutter for left atrial thrombus or spontaneous contrast when a decision has been made to anticoagulate and not to perform cardioversion	I (3)

General Discussion

The appropriateness criteria in this report provide an estimate of the reasonableness of the use of TTE/TEE for the particular clinical scenario presented in each of the 59 indications considered. They 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 appropriateness criteria for SPECT nuclear imaging (13) and cardiac CT and MR (14) has shown great value across a broad range of situations, guiding care of individual patients, educating caregivers, and informing policy decisions regarding reimbursement for cardiovascular imaging.

Appropriateness criteria represent the first component of the chain of quality recommended for cardiovascular imaging (15). 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 all are addressed in this report. The development of appropriateness criteria and their ranking by the Technical Panel assumes that other quality standards are adequately met. It also is assumed that when considering the appropriateness of ordering a repeat or annual test the prior image and report can be obtained and are of sufficient quality as previously outlined.

Although the appropriateness ratings reflect the general assessment of when TTE or TEE may or may not be useful for specific patient populations, physicians and other stakeholders should understand the role of clinical judgment in determining whether to order a test for an individual patient. For example, the rating of an indication as inappropriate should not preclude a provider from performing echocardiographic procedures when there are patient- and condition-specific data to support that decision. Indeed, this may be the correct clinical pathway if supported by mitigating characteristics of the patient. Likewise, 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 (4–6) should not be viewed as limiting the use of echocardiography for such patients. Finally, there may be clinical situations in which the use of echocardiography for an indication considered to be appropriate does not always represent reasonable practice, such as for a patient in whom another diagnostic imaging test might be scheduled or has already been performed.

The indications contained in this report are purposefully broad to capture the range of situations in which clinicians find value in echocardiographic information. However, as with the appropriateness criteria for other imaging modalities, they are not exhaustive due to the complexity and number of potential clinical situations. Similarly, current disease-based guidelines include additional recommendations concerning the use of echocardiography that are not included in the set of indications presented in this paper. For example, the chronic stable angina guideline (16) includes a Class III recommendation discouraging the use of echocardiography for symptomatic patients with a normal ECG, no history of MI, and without symptoms or signs suggestive of chronic heart failure. The recommendations of such guidelines remain a part of ACC/AHA clinical policy, and should continue to guide care. Additionally, there may be reasons that would preclude the application of the appropriateness criteria to a specific patient, and clinical judgment should be used at all times in the application of these criteria.

Echocardiography tests, like many imaging tests, may provide additional useful information beyond the primary purpose outlined by the indication. The appropriateness criteria for TTE/TEE were not developed to quantify the incremental information that could be obtained by performing the test for reasons beyond those stated in an individual indication. Thus, members of the Technical Panel were asked specifically not to consider implicit or additional information outside the scope of an individual indication in their rankings. As such, the entire list of indications should be reviewed to assess the full range of potential reasons for ordering an echocardiogram for an individual patient. In addition, panelists were asked not to consider comparisons to other imaging procedures or other appropriateness criteria documents while completing their rankings, but to instead consider the particular echocardiography test on its own merits. As such, the scores and conclusions about appropriateness also should not be directly compared with the prior report for appropriateness for SPECT myocardial perfusion imaging (13), cardiovascular computed tomography, or cardiovascular magnetic resonance (14).

There are many potential applications for appropriateness criteria. Clinicians could use the ratings as a decision support or educational tool when ordering a test or providing a referral to another qualified physician. The criteria also may be used as a discussion tool with a referring physician who has a suggested pattern of ordering tests for inappropriate indications. Facilities and payers may choose to use the criteria either prospectively in the design of protocols and pre-authorization procedures, or retrospectively for quality reports. It is hoped that payers will use this document as the basis for their own strategies to ensure that their members receive quality, cost-effective cardiovascular care.

As outlined in the original methodology by ACCF (1), it is expected that services performed for appropriate indications will receive reimbursement. In contrast, services performed for inappropriate indications will likely require additional documentation to justify payment because of unique circumstances or the clinical profile of the patient. Payers should note that the Technical Panel and clinical community do not consider uncertain indications as those that should not be performed or reimbursed. Rather, the uncertain indications are those where the opinions of the panel varied and the data may be conflicting. In many of these areas, additional research is clearly desirable. Indications with high clinical volume that are rated as uncertain may suggest areas for increased focus and research.

When used to assess performance, appropriateness criteria should be used in conjunction with systems that support quality improvement. Ordering forms containing essential information for determining appropriateness along with periodic feedback reports to providers may help educate providers on their ordering patterns. Prospective pre-authorization procedures, if put in place, may be used most effectively once a retrospective review has identified a pattern of potential inappropriate use. Because the criteria are based on current scientific evidence and the deliberations of the Technical Panel, they can be used prospectively to help resolve *future* reimbursement cases or appeals but should *not* be applied retrospectively to cases completed prior to issuance of this report.

The primary objective of this report is to provide guidance regarding the perceived suitability of echocardiography for diverse clinical scenarios. As with previous appropriateness

criteria documents, consensus among the raters was desirable, but any attempt to achieve complete agreement within this diverse panel would have been artificial and not necessarily of clinical value. Two rounds of ratings with lively discussion between 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.

Future research analyzing patient outcomes utilizing indications rated appropriate would help ensure the equitable and efficient allocation of resources for diagnostic studies. Review of medically necessary care may also improve the understanding of regional variations in imaging utilization. Further exploration of the indications rated as "uncertain" will help generate the data required to further define the appropriateness of echocardiography. Finally, it will be necessary to periodically assess and update the indications and criteria as technology evolves and new data and field experience becomes available.

Appendix A: TTE/TEE Defintions

Atrial premature contraction: a depolarization of the atrium which occurs with a coupling interval shorter than that resulting from the intrinsic heart rhythm.

Chest pain syndrome or anginal equivalent (acute): any constellation of acute symptoms that the physician feels may represent a complaint consistent with obstructive coronary artery disease. Examples of such symptoms include, but are not exclusive to, chest pain, chest tightness, burning, dyspnea, shoulder pain, palpitations, syncope, breathlessness, and jaw pain.

Clinical status: clinically meaningful indicators of a specified condition, including signs, symptoms, physical examination, and/or functional status.

Intracardiac device: any pacing device or implantable cardioverter-defibrillator including pacemakers and/or CRTs.

Left ventricular function (normal): greater than or equal to 50% ejection fraction.

Mitral valve prolapse (suspected): the auscultatory findings in mitral valve prolapse, when present, may consist of a click or multiple clicks that move within systole with changes in LV dimensions and/or a late systolic or holosystolic murmur of MR.

Mitral valve prolapse: valve prolapse of 2 mm or more above the mitral annulus in the long-axis parasternal view and other views.

Murmurs (reasonable suspicion): does *not* have the characteristics of innocent murmurs. The characteristics of innocent murmurs in asymptomatic adults that have no functional significance include the following:

- Grade 1 to 2 intensity at the left sternal border
- a systolic ejection pattern
- normal intensity and splitting of the second heart sound
- no other abnormal sounds or murmurs
- no evidence of ventricular hypertrophy or dilatation, and
- the absence of increased murmur intensity with the Valsalva maneuver or with standing from a squatting position.

Such murmurs are especially common in high-output states such as anemia and pregnancy. When the characteristic features of individual murmurs are considered together with information obtained from the history and physical examination, the correct diagnosis can usually be established.

Native valvular regurgitation (mild, moderate, severe): see Table 11. Classification of the Severity of Valve Disease in Adults (17).

Native valvular stenosis (mild, moderate, severe): see Table 11. Classification of the Severity of Valve Disease in Adults (17).

Pacing device: any implanted cardiac device designed to pace the contraction of the heart including CRT and traditional pacemakers, with or with implantable cardioverter-defibrillator capability.

Premature ventricular contraction: a depolarization of the ventricle that occurs with a coupling interval shorter than that resulting from the intrinsic heart rhythm.

Supraventricular tachycardia: a tachycardia that emanates from or requires participation of supraventricular tissue. These tachycardias can be either persistent or paroxysmal.

- Atrial tachycardias other than atrial fibrillation and flutter
- AV node re-entry
- AV re-entry

Suspected cardiac etiology (concerning for structural heart disease): reasonable clinical concern for structural heart disease based on but not limited to findings on history, physical exam findings, or other prior test results.

Ventricular tachycardia: a cardiac arrhythmia of 3 or more consecutive complexes in duration emanating from the ventricles at a rate greater than 100 beats per min (cycle length less than 600 ms).

Appendix B: Methods

Panel Selection

Stakeholders were given the opportunity to participate in the appropriateness criteria process by submitting nominees from their organizations through a Call for Nominations released in the summer of 2006. From this list of nominees, the Working Group selected panel members to ensure an appropriate balance with respect to expertise in the specific modality, referring physicians, academic versus private practice, health services research, and specialty training.

Table 11. Classification of the Severity of Valve Disease in Adults

A. Left-sided valve disease

	Aortic Stenosis		
Indicator	**Mild**	**Moderate**	**Severe**
Jet velocity (m per second)	Less than 3.0	3.0–4.0	Greater than 4.0
Mean gradient (mm Hg)*	Less than 25	25–40	Greater than 40
Valve area (cm^2)	Greater than 1.5	1.0–1.5	Less than 1.0
Valve area index (cm^2 per m^2)			Less than 0.6
	Mitral Stenosis		
	Mild	**Moderate**	**Severe**
Mean gradient (mm Hg)*	Less than 5	5–10	Greater than 10
Pulmonary artery systolic pressure (mm Hg)	Less than 30	30–50	Greater than 50
Valve area (cm^2)	Greater than 1.5	1.0–1.5	Less than 1.0
	Aortic Regurgitation		
	Mild	**Moderate**	**Severe**
Qualitative			
Angiographic grade	1+	2+	3–4+
Color Doppler jet width	Central jet, width less than 25% of LVOT	Greater than mild but no signs of severe AR	Central jet, width greater than 65% LVOT
Doppler vena contracta width (cm)	Less than 0.3	0.3–0.6	Greater than 0.6
Quantitative (cath or echo)			
Regurgitant volume (ml per beat)	Less than 30	30–59	Greater than or equal to 60
Regurgitant fraction (%)	Less than 30	30–49	Greater than or equal to 50
Regurgitant orifice area (cm^2)	Less than 0.10	0.10–0.29	Greater than or equal to 0.30
Additional essential criteria			
Left ventricular size			Increased
	Mitral Regurgitation		
	Mild	**Moderate**	**Severe**
Qualitative			
Angiographic grade	1+	2+	3–4+
Color Doppler jet area	Small, central jet (less than 4 cm^2 or less than 20% LA area)	Signs of MR greater than mild present but no criteria for severe MR	Vena contracta width greater than 0.7 cm with large central MR jet (area greater than 40% of LA area) or with a wall-impinging jet of any size, swirling in LA
Doppler vena contracta width (cm)	Less than 0.3	0.3–0.69	Greater than or equal to 0.70
Quantitative (cath or echo)			
Regurgitant volume (ml per beat)	Less than 30	30–59	Greater than or equal to 60
Regurgitant fraction (%)	Less than 30	30–49	Greater than or equal to 50
Regurgitant orifice area (cm^2)	Less than 0.20	0.2–0.39	Greater than or equal to 0.40
Additional essential criteria			
Left atrial size			Enlarged
Left ventricular size			Enlarged

B. Right-sided valve disease	**Characteristic**
Severe tricuspid stenosis:	Valve area less than 1.0 cm^2
Severe tricuspid regurgitation:	Vena contracta width greater than 0.7 cm and systolic flow reversal in hepatic veins
Severe pulmonic stenosis:	Jet velocity greater than 4 m per second or maximum gradient greater than 60 mm Hg
Severe pulmonic regurgitation:	Color jet fills outflow tract; dense continuous wave Doppler signal with a steep deceleration slope

*Valve gradients are flow dependent and when used as estimates of severity of valve stenosis should be assessed with knowledge of cardiac output or forward flow across the valve. Modified from the *Journal of the American College of Cardiology*, *48*, Bonow RO, Carabello BA, Chatterjee K, et al. ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 1998 Guidelines for the Management of Patients With Valvular Heart Disease) (17).

AR = aortic regurgitation; cath = catheterization; echo = echocardiography; LA = left atrial/atrium; LVOT = left ventricular outflow tract; MR = mitral regurgitation.

Development of Indications

The process for creating a robust set of indications involved consulting current literature and previously published guidelines and clinical policy statements. The indications capture the majority of scenarios faced by cardiologists or referring physicians, but are not meant to be inclusive of all potential indications for which echocardiography studies may be performed. Review was done by the Working Group, including additional comments from external reviewers. As a result of the meeting of the Technical Panel prior to the second round of rating, a number of the indications were clarified and modified. A final set of indications comprised the list of possible clinical scenarios that were rated for appropriateness by the panelists and compiled for this report.

Rating Process

The Technical Panel was instructed to follow the process outlined in the article previously published by the College titled, "ACCF Proposed Method for Evaluating the Appropriateness of Cardiovascular Imaging" (1). The appropriateness method combines expert clinical judgment with the scientific literature in evaluating the benefits and risks of medical procedures. Each panel member has equal weight in producing the final result for the set of indications they are asked to rate, and the method does not force consensus.

The rating process includes a modified Delphi process involving 2 rounds of ratings and an intervening face-to-face meeting. At the face-to-face meeting, each panelist received a personalized rating form that indicated his/her rating for each indication and the distribution of de-identified ratings of other members of the panel. In addition, the moderator received a summary rating form with similar information (including panelist identification), along with other statistics that measured the level of agreement among panel members. A measure of the level of disagreement was applied to each score after both the first and second round scoring was completed. This project employed the BIOMED Concerted Action on Appropriateness definition for a panel size of 14 to 16. As defined in the RAND/UCLA manual (12) upon which the ACCF ratings method is based, the BIOMED rule for agreement (+) is that no more than 4 panelists rate the indication outside the 3-point region containing the median; for disagreement (−), at least 5 panelists rate in each extreme rating region (i.e., 1 to 3 and 7 to 9). Measures of agreement and the dispersion of ratings (mean absolute deviation from the median) may highlight areas where definitions are not clear or ratings are inconsistent, where panelist perceptions of the "average" patient may differ, or where various specialty groups or individual panelists may have differences of clinical opinion. In cases of obvious disagreement or outlier scores, the indication was highlighted in a summary table and identification of the outlier raters brought to the attention of the moderator. This information was used by the moderator to guide the panel's discussion.

Relationships With Industry

The College and its partnering organizations rigorously avoid any actual, perceived, or potential conflicts of interest that might arise as a result of an outside relationship or personal interest of a member of the Technical Panel. Specifically, all panelists are asked to provide disclosure statements of all relationships that might be perceived as real or potential conflicts of interest. These statements were reviewed by the Appropriateness Criteria 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 each Technical Panel and Oversight Working Group member can be found in Appendix D.

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 B at http://www.acc.org). Lastly, they were provided Web links to the previously published materials pertaining to the appropriateness criteria work (1,13,14).

Appendix C: ACCF Appropriateness Criteria Working Group and Technical Panels

Echocardiography Writing Group

Pamela S. Douglas, MD, MACC, FAHA, FASE: Lead Author, Appropriateness Criteria for Echocardiography—Past President, ACC; Past President ASE; and Ursula Geller Professor of Research in Cardiovascular Diseases and Chief, Cardiovascular Disease, Duke University Medical Center, Durham, NC

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TTE/TEE Technical Panel

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NCDR Management Board, American College of Cardiology, Washington, DC

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Michael H. Picard, MD, FACC, FAHA—President, American Society of Echocardiography; Associate Professor of Medicine, Harvard Medical School, Boston, MA; Director, Clinical Echocardiography, Massachusetts General Hospital, Boston, MA

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ACCF Appropriateness Criteria Working Group

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Michael J. Wolk, MD, MACC—Past President, ACC and Clinical Professor of Medicine, Weill-Cornell Medical School, New York, NY

Joseph M. Allen, MA—Director, TRIP (Translating Research Into Practice), Washington, DC

APPENDIX D. ACCF/ASE/ACEP/ASNC/SCAI/SCCT/SCMR TTE/TEE Appropriateness Criteria Writing Group, Technical Panel, Working Group, and Indication Reviewers—Relationships With Industry (in alphabetical order)

Committee Member	Research Grant	Speakers Bureau/ Honoraries/ Expert Witness	Stock Ownership	Board of Directors	Consultant/ Scientific Advisory Board/ Steering Committee
TTE/TEE Appropriateness Criteria Writing Group					
Dr. Pamela S. Douglas	None	None	None	None	• GE Healthcare
Dr. Bijoy Khandheria	None	None	None	None	None
Dr. Raymond F. Stainback	None	None	None	None	None
Dr. Neil J. Weissman	• Acusphere • Arena Pharmaceutical • Bristol-Myers Squibb Imaging • Carbamedics • Edwards • Medtronic • St. Jude's	None	None	None	• Pfizer • Wyeth
TTE/TEE Appropriateness Criteria Technical Panel					
Dr. Joseph S. Alpert	None	None	None	None	None
Dr. Ralph G. Brindis	None	None	None	None	None
Dr. David Fitzgerald	• Guidant • Johnson & Johnson • Medtronic • St. John Medical • Wyeth	None	None	None	None
Dr. Paul Heidenreich	None	None	None	None	None
Dr. Bijoy Khandheria	None	None	None	None	None
Dr. Edward T. Martin	• GE Healthcare	• GE Healthcare	None	None	• GE Healthcare
Dr. Joseph V. Messer	None	None	None	None	None
Dr. Alan B. Miller	• Medtronic • Nitromed • Otsuka • Pfizer	• AstraZeneca • Bristol-Myers Squibb • CV Therapeutics • GlaxoSmithKline • King • Medtronic • Nitromed • Novartis • Pfizer • Sanofi • Scios	None	None	None
Dr. Manesh R. Patel	None	None	None	None	• Amgen • Genzyme
Dr. Michael H. Picard	None	None	None	None	• Acusphere
Dr. Paolo Raggi	None	None	None	None	None
Dr. Kim D. Reed	None	None	None	None	None
Dr. John S. Rumsfeld	None	None	None	None	None
Dr. Anthony E. Steimle	None	None	None	None	None
Dr. Russ Tonkovic	None	None	None	None	None
Dr. Krishnaswami Vijayaraghavan	• Activbiotics, Inc. • Amgen • AstraZeneca • Bristol-Myers Squibb • KOS • Medtronic • Merck • Novartis • Otsuka • Pfizer • Reliant • Sanofi-Aventis • SCIOS • Takeda	• AstraZeneca • CV Therapeutics • Medtronic • Novartis • Scios	None	None	• AstraZeneca • CV Therapeutics • Sanofi-Aventis

APPENDIX D. Continued

Committee Member	Research Grant	Speakers Bureau/ Honoraries/ Expert Witness	Stock Ownership	Board of Directors	Consultant/Scientific Advisory Board/ Steering Committee
Dr. Neil J. Weissman	• Acusphere • Arena Pharmaceutical • Bristol-Myers Squibb Imaging • Carbamedics • Edwards • Medtronic • St. Jude's	None	None	None	• Pfizer • Wyeth
Dr. Susan Bok Yeon	None	None	None	None	None
ACCF Appropriateness Criteria Working Group					
Joseph M. Allen	None	None	None	None	None
Dr. Ralph G. Brindis	None	None	None	None	None
Dr. Pamela S. Douglas	None	None	None	None	• GE Healthcare
Dr. Robert C. Hendel	• Astellas Healthcare • Cornatus Genetics • GE Healthcare	• Bristol-Myers Squibb			• GE Healthcare
Dr. Manesh R. Patel	None	None	None	None	• Amgen • Genzyme
Dr. Eric Peterson	• Bristol-Myers Squibb/ Sanofi • Millennium Pharmaceuticals • Schering-Plough				
Dr. Michael J. Wolk	None	None	None	None	None
TTE/TEE Appropriateness Criteria Indication Reviewers					
Dr. Robert Bonow	None	None	None	None	None
Dr. Roberto M. Lang	• Pfizer • Philips • Point Biomedical • Sonosile • Tomtec	• Philips • Tomtec	None	None	• Abbott
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REFERENCES

1. 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.
2. 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.
3. Intersocietal Commission for the Accreditation of Echocardiography Laboratories. Standards for Organizations and for Testing. Available at: http://www.intersocietal.org/icael/apply/standards.htm. Accessed May 1, 2007.
4. Beller, GA, Bonow, RO, Fuster, V. ACC revised recommendations for training in adult cardiovascular medicine. Core Cardiology Training II (COCATS 2) (revision of the 1995 COCATS training statement). J Am Coll Cardiol 2002;39:1242–6.
5. Quiñones, GA, Douglas, PS, Foster, E, et al. ACC/AHA clinical competence statement on echocardiography: a report of the American College of Cardiology/American Heart Association/American College of Physicians-American Society of Internal Medicine Task Force on Clinical Competence Developed in Collaboration with the American Society of Echocardiography, the Society of Cardiovascular Anesthesiologists, and the Society of Pediatric Echocardiography J Am Coll Cardiol 2003;41:687–708.
6. Shanewise JS, Cheung AT, Aronson S, et al. ASE/SCA guidelines for performing a comprehensive intraoperative multiplane transesophageal echocardiography examination: recommendations of the American Society of Echocardiography Council for Intraoperative Echocardiography and the Society of Cardiovascular Anesthesiologists Task Force for Certification in Perioperative Transesophageal Echocardiography. Anesth Analg 1999;89:870–84.
7. Henry WL, DeMaria A, Gramiak R, et al. Report of the American Society of Echocardiography committee on nomenclature and standards in two-dimensional echocardiography. Circulation 1980;62:212–5.
8. Cheitlin MD, Armstrong WF, Aurigemma GP, et al. ACC/AHA/ASE 2003 guideline update for the clinical application of echocardiography: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/ASE Committee to Update the 1997 Guidelines for the Clinical Application of Echocardiography). J Am Coll Cardiol 2003;42:954–70.

9. Waggoner AD, Ehler D, Adams D, et al. Guidelines for the cardiac sonographer in the performance of contrast echocardiography: Recommendations of the American Society of Echocardiography Council on Cardiac Sonography. J Am Soc Echocardiogr 2001;14:417–20.
10. Zoghbi WA, Enriquez-Sarano M, Foster E, et al. Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography. J Am Soc Echocardiogr 2003;16:777–802.
11. Mulvagh SL, DeMaria AN, Feinstein SB, et al. Contrast echocardiography: current and future applications. J Am Soc Echocardiogr 2000;13:331–42.
12. Fitch K, Bernstein JJ, Aguilar MD, et al. The RAND/UCLA Appropriateness Method User's Manual. Arlington, VA: RAND, 2001.
13. 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.
14. 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: a report of the American College of Cardiology Foundation/American College of Radiology, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, American Society of Nuclear Cardiology, North American Society for Cardiac Imaging, Society for Cardiovascular Angiography and Interventions, and Society of Interventional Radiology. J Am Coll Cardiol 2006;48:1475–97.
15. 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.
16. 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 (Committee on the Management of Patients With Chronic Stable Angina). J Am Coll Cardiol 2003;41:159–68.
17. Bonow RO, Carabello BA, Chatterjee K, et al. ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 1998 Guidelines for the Management of Patients With Valvular Heart Disease). J Am Coll Cardiol 2006;48:e1–148.

APPENDIX

Supplementary data associated with this article can be found in the online version.