ACC/AHA Guidelines for Coronary Angiography: Executive Summary and Recommendations : A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Coronary Angiography) Developed in collaboration with the Society for Cardiac Angiography and Interventions

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Developed in collaboration with the Society for Cardiac Angiography and Interventions

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This document revises and updates the original "Guidelines for Coronary Angiography," published in 1987. This executive summary and recommendations appears in the May 4, 1999, issue of *Circulation*. The guidelines in their entirety, including the American College of Cardiology/American Heart Association (ACC/AHA) class I, II, and III recommendations, are published in the May 1999 issue of the *Journal of the American College of Cardiology*. Reprints of both the full text and executive summary and recommendations are available from both organizations.

The frequent and still growing use of coronary angiography, its relatively high costs, its inherent risks, and the ongoing evolution of its indications provide the reasons for this revision. The committee appointed to develop this document included private practitioners and academicians who were selected to represent both experts in coronary angiography and senior clinician consultants. Representatives from the family practice and internal medicine professions were also included on the committee. In addition to reviewing the original document, the committee conducted a search of the literature for the 10 years preceding development of these guidelines. Evidence was compiled and ranked by the committee. Whereas randomized trials are often available for reference in the development of treatment guidelines, randomized trials regarding the use of diagnostic procedures such as coronary angiography are rarely available.

This document uses the ACC/AHA classifications of class I, II, and III. These classes summarize the indications for coronary angiography as follows:

Class I: Conditions for which there is evidence and/or general agreement that this procedure is useful and effective.

"ACC/AHA Guidelines for Coronary Angiography: Executive Summary and Recommendations" was approved by the American College of Cardiology Board of Trustees in October 1998 and by the American Heart Association Science Advisory and Coordinating Committee in December 1998.

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This document is available on the World Wide Web sites of the American College of Cardiology (www.acc.org) and the American Heart Association (www.americanheart.org). A single reprint of the executive summary and list of recommendations is available by calling 800-242-8721 (US only) or writing the American Heart Association, Public Information, 7272 Greenville Ave, Dallas, TX 75231-4596. Ask for reprint No. 71-0164. To obtain a reprint of the full text published in the May 1999 issue of the *Journal of the American College of Cardiology*, ask for reprint No. 71-0163. To purchase additional reprints (specify version and reprint number): Up to 999 copies, call 800-611-6083 (US only) or fax 413-665-2671; 1000 or more copies call 214-706-1466, fax 214-691-6342, or E-mail pubauth@heart.org.

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Class II: Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of performing the procedure.

Class IIa: Weight of evidence/opinion is in favor of usefulness/ efficacy.

Class IIb: Usefulness/efficacy is less well established by evidence/opinion.

Class III: Conditions for which there is evidence and/or general agreement that the procedure is not useful/effective and in some cases may be harmful.

The weight of evidence in support of the recommendation for each listed indication is presented as follows:

Level of Evidence A: The presence of multiple randomized clinical trials.

Level of Evidence B: The presence of a single randomized trial or nonrandomized studies.

Level of Evidence C: Expert consensus.

The full report discusses some general considerations concerning the definition and purpose of coronary angiography, its accuracy and reproducibility, including a discussion of digital storage of coronary angiography, its limitations, risks and relative contraindications, the selection of a contrast agent for coronary angiography, pharmacological assessment for coronary spasm at the time of coronary angiography, and the use, cost, and cost-effectiveness of coronary angiography. This executive summary does not detail these general considerations, and the reader is referred to the full document for discussion of these important topics.

The full document also discusses applications of coronary angiography in specific disease states and makes recommendations for its appropriate use in these conditions. This executive summary includes highlights of these discussions and a complete list of recommendations.

The full document contains appendices that present definitions of angiographic coronary anatomy, special considerations, alternative imaging modalities, the Canadian Cardiovascular Society (CCS) classification of angina and the desired elements of a coronary angiographic report. This executive summary does not include any of the discussions in these appendices, but recommendations for the use of alternative imaging modalities are included at the end of this summary.

This report is not intended to provide strict indications or contraindications for coronary angiography because, in the individual patient, multiple other considerations may be relevant, including the family setting, occupational needs, and individual lifestyle preferences. Rather, the report is intended to provide general guidelines that may be helpful to the practitioner and various healthcare agencies.

I. General Considerations Regarding Coronary Angiography

Coronary angiography is defined as the radiographic visualization of the coronary vessels after injection of radiopaque contrast media. It is most commonly performed with specialized intravascular catheters. The procedure is usually included as part of cardiac catheterization, which may also involve angiography of other vascular structures, such as the aorta and left ventricle.

The purpose of coronary angiography is to define the coronary anatomy and the degree of luminal obstruction of the coronary arteries. It is most commonly used to determine the presence and extent of obstructive coronary artery disease (CAD) and to assess the feasibility and appropriateness of various forms of therapy, such as revascularization by percutaneous or surgical interventions. It is also used when the diagnosis of coronary disease is uncertain and coronary disease cannot be reasonably excluded by noninvasive techniques.

The risk of major complications is $<2\%$, but factors such as the stability of the patient's condition, the presence of shock, acute renal insufficiency, and cardiomyopathy significantly increase risk. A number of relative contraindications to the procedure have been reported. Of these, preexisting renal failure, particularly in a patient with diabetes, and a history of prior anaphylactic reaction to contrast medium require special attention before coronary angiography to reduce the risk of subsequent complications.

Cardiac catheterization was performed in $>1\,000\,000$ patients in 1993, making it the second most frequent in-hospital operative procedure performed in the United States. Approximately 48% of all catheterizations are performed in patients ≥ 65 years. The use of catheterization continues to grow. Given the predicted growth in population and aging of the population, it is possible that by 2010 3 000 000 procedures will be performed annually in the United States. The striking variations in use of coronary angiography in the United States have led to concerns about its appropriateness. A number of studies have evaluated this issue, and the results suggest that the incidence of inappropriate use of coronary angiography is relatively low, ranging from 4% to 18%.

II. Coronary Angiography for Specific Conditions

A. Known or Suspected CAD

1. Stable Angina

Patients with CAD may become symptomatic in many ways, but most commonly develop angina pectoris. Not all stable chest pain syndromes are truly anginal. It has been suggested that it is useful to characterize chest pain as typical angina, probable angina, and nonspecific chest pain because these groupings are predictive of the presence of CAD.

Asymptomatic patients with known or suspected CAD have had no symptoms to suggest cardiac ischemia in the previous 6 weeks. A subgroup of these patients have silent ischemia when tested noninvasively. In general, the results of these tests are related to the functional severity of CAD and are predictors of outcome, independent of the perception of or severity of symptoms. The term *known coronary artery disease* means that CAD has been documented by either angiography or prior confirmed myocardial infarction (MI). Asymptomatic patients with known CAD form 1 group of patients who were never symptomatic but in whom CAD was documented for other reasons. A second group includes those who were previously symptomatic but who are currently asymptomatic. The term *suspected coronary artery disease* refers to the presence of clinical characteristics that suggest

TABLE 1. Noninvasive Test Results Predicting High Risk* for Adverse Outcome

1.	Severe resting left ventricular dysfunction (LVEF<35%)
2.	High-risk treadmill score (score≤−11)
3.	Severe exercise left ventricular dysfunction (exercise LVEF<35%)
4.	Stress-induced large perfusion defect (particularly if anterior)
5.	Stress-induced moderate-size multiple perfusion defects
6.	Large, fixed perfusion defect with left ventricular dilatation or increased lung uptake (^{201}Tl)
7.	Stress-induced moderate-size perfusion defect with left-ventricular dilatation or increased lung uptake (^{201}Tl)
8.	Echocardiographic wall motion abnormality (involving >2 segments) developing at low dose of dobutamine (≤10 mg · kg^{-1} · min^{-1}) or at a low heart rate (<120 bpm)
9.	Stress echocardiographic evidence of extensive ischemia

*Greater than 3% annual mortality rate.
bpm indicates beats per minute.

high risk for CAD and its related adverse outcomes in asymptomatic patients.

Treatment of symptomatic patients should include assessment of severity of angina. The CCS classification of angina provides a useful guide for assessment of typical or probable angina. Severely symptomatic patients (CCS class III or IV) should undergo coronary angiography after medical therapy. Coronary angiography should also be considered for patients treated medically who demonstrate serial deterioration on noninvasive testing but who do not have high-risk features as well as patients whose angina accelerates or intensifies despite adequate medical therapy. Rarely, patients with minimal symptoms whose occupation poses a risk to themselves or others should also undergo coronary angiography, even in the absence of high-risk markers for adverse outcome. Those patients with stable angina who respond to therapy and are currently asymptomatic should undergo noninvasive testing for risk stratification. Table 1 summarizes noninvasive test results that predict high risk for adverse outcome. High-risk patients are defined as those who are expected to have reduced event-free survival, such as patients with underlying left main coronary artery stenosis or severe multivessel disease. In general, the lower the resting left ventricular ejection fraction (LVEF), the higher the risk for adverse outcome. Figure 1 explains the Duke Treadmill Score and its relationship to prognosis. Even when multiple clinical findings suggest the likelihood of significant underlying coronary

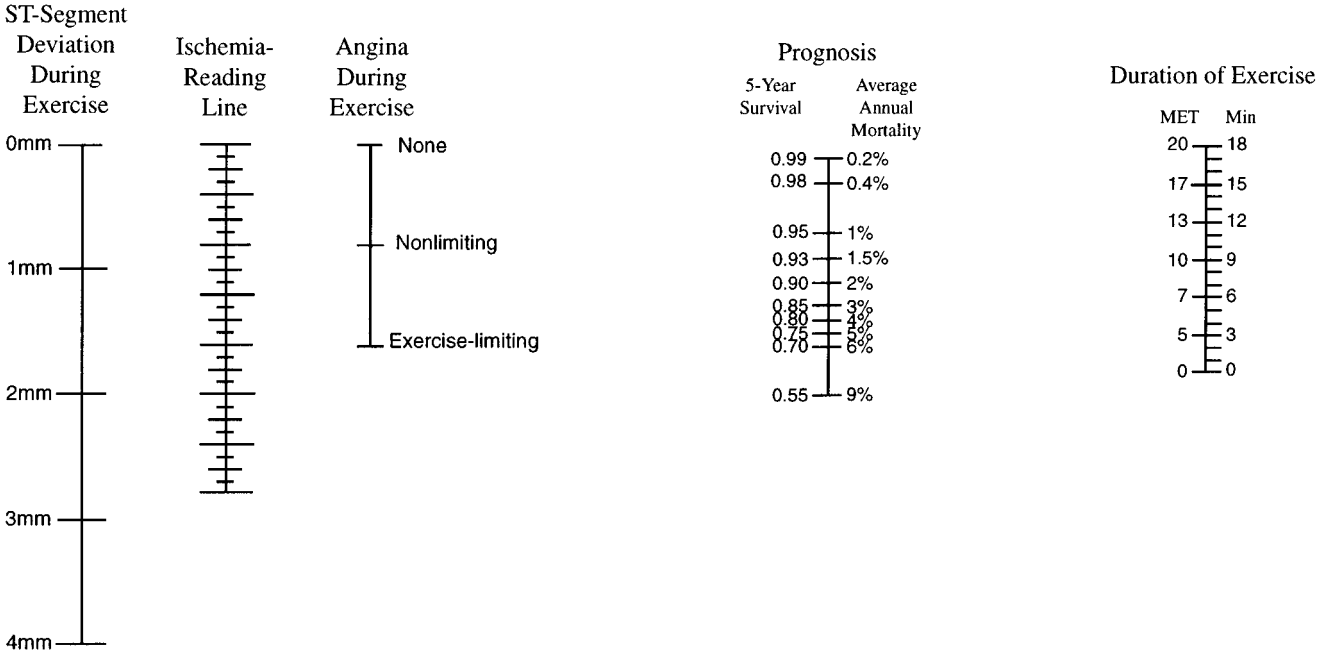

Figure 1. Nomogram of prognostic relations embodied in the Duke Treadmill Score. Determination of prognosis proceeds in 5 steps:

1. The observed amount of exercise-induced ST-segment deviation (the largest elevation or depression after resting changes have been subtracted) is marked on the line for ST-segment deviation during exercise.
2. The observed degree of angina during exercise is marked on the line for angina.
3. The marks for ST-segment deviation and degree of angina are connected with a straight edge. The point where this line intersects the ischemia reading line is noted.
4. The total number of minutes of exercise in treadmill testing according to the Bruce protocol (or the equivalent in multiples of resting oxygen consumption [METs] from an alternative protocol) is marked on the exercise-duration line.
5. The mark for ischemia is connected with that for exercise duration. The point at which this line intersects the line for prognosis indicates the 5-year survival rate and average annual mortality for patients with these characteristics.

Patients with <1 mm of exercise-induced ST-segment depression should be counted as having 0 mm. Angina during exercise refers to typical effort angina or an equivalent exercise-induced symptom that represents the patient's presenting complaint. This nomogram applies to patients with known or suspected CAD, without prior revascularization or recent MI, who undergo exercise testing before coronary angiography.

Modified with permission from Mark DB, Shaw L, Harrell FE Jr, et al. Prognostic value of a treadmill exercise score in outpatients with suspected coronary artery disease. *N Engl J Med.* 1991;325:849–853.

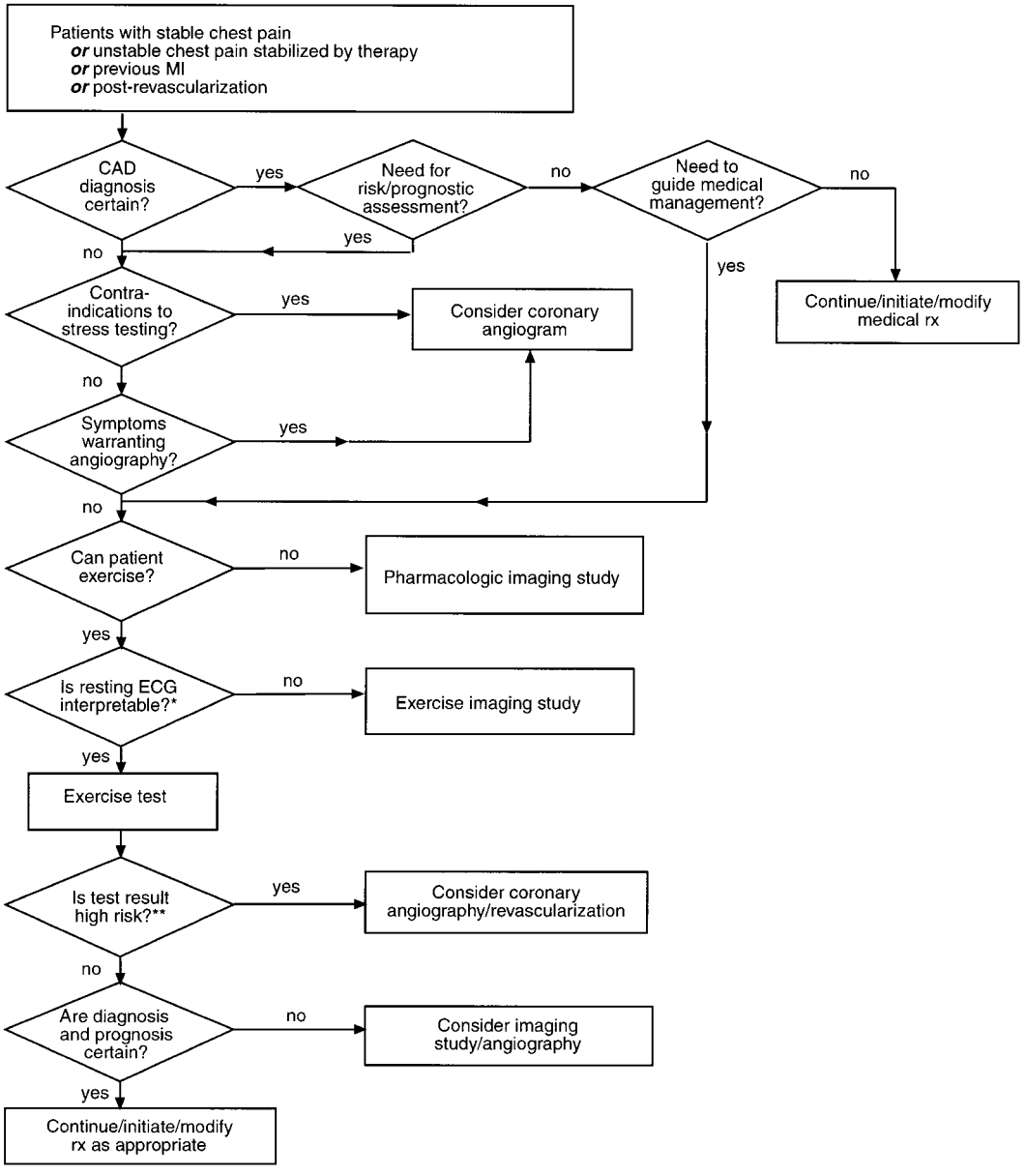

Figure 2. Clinical context for noninvasive and invasive diagnostic testing of patients with known or suspected ischemic heart disease. *ECG interpretable unless preexcitation, electronically paced rhythm, left BBB, or resting ST-segment depression >1 mm. See text for discussion of use of digoxin, left ventricular hypertrophy, and ST-segment depression <1 mm. **For example, high risk if Duke treadmill score predicts average annual mortality >3%. Modified from 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.

disease, it is important to have objective markers from noninvasive tests to help predict outcome. A scheme for noninvasive evaluation of a patient with suspected coronary disease is shown in Figure 2. Noninvasive procedures for identifying patients with stress-induced ischemia, especially those at high risk for adverse outcome, should remain the primary means of risk stratification. There is general agreement that coronary angiography is indicated for patients found to have high-risk abnormalities on noninvasive testing. There is varying opinion as to when coronary angiography should be performed in asymptomatic patients for whom noninvasive testing indicates ischemia (ie, a high probability of CAD), but test criteria do not indicate a high risk for adverse outcome. In this subgroup, the presence of multiple clinical risk factors such as increased age or diabetes, occupation, or lifestyle become increasingly important considerations in determining whether coronary angiography should be performed. However, it should be recognized that no controlled studies show an advantage for angiography or revascularization for any of these clinical subsets.

Although it has become common practice to perform periodic coronary angiography after heart transplantation, the prognostic benefit of this practice has not been clearly established.

Adult patients successfully resuscitated from cardiac arrest who do not have clinical findings that suggest other causes

generally have extensive CAD. In the absence of recognized precipitating factors such as acute MI, these patients are at high risk for recurrent cardiac arrest, and coronary angiography is of value in determining the underlying cause and planning the most appropriate therapeutic approach.

Recommendations for Coronary Angiography in Patients With Known or Suspected CAD Who Are Currently Asymptomatic or Have Stable Angina

Class I

1. **CCS class III and IV angina on medical treatment. *(Level of Evidence: B)***
2. **High-risk criteria on noninvasive testing regardless of anginal severity (Table 1). *(Level of Evidence: A)***
3. **Patients who have been successfully resuscitated from sudden cardiac death or have sustained (>30 seconds) monomorphic ventricular tachycardia or nonsustained (<30 seconds) polymorphic ventricular tachycardia. *(Level of Evidence: B)***

Class IIa

1. **CCS class III or IV angina, which improves to class I or II with medical therapy. *(Level of Evidence: C)***
2. **Serial noninvasive testing with identical testing protocols, at the same level of medical therapy, showing progressively worsening abnormalities. *(Level of Evidence: C)***
3. **Patients with angina and suspected coronary disease who, due to disability, illness, or physical challenge, cannot be adequately risk stratified by other means. *(Level of Evidence: C)***
4. **CCS class I or II angina with intolerance to adequate medical therapy or with failure to respond, or patients who have recurrence of symptoms during adequate medical therapy as defined above. *(Level of Evidence: C)***
5. **Individuals whose occupation involves the safety of others (eg, pilots, bus drivers, etc) who have abnormal but not high-risk stress test results or multiple clinical features that suggest high risk. *(Level of Evidence: C)***

Class IIb

1. **CCS class I or II angina with demonstrable ischemia but no high-risk criteria on noninvasive testing. *(Level of Evidence: C)***
2. **Asymptomatic man or postmenopausal woman without known coronary heart disease with ≥2 major clinical risk factors and abnormal but not high-risk criteria on noninvasive testing (performed for indications stated in the ACC/AHA noninvasive testing guidelines). *(Level of Evidence: C)***
3. **Asymptomatic patients with prior MI with normal resting left ventricular function and ischemia on noninvasive testing but without high-risk criteria. *(Level of Evidence: C)***
4. **Periodic evaluation after cardiac transplantation. *(Level of Evidence: C)***
5. **Candidate for liver, lung, or renal transplant ≥40 years old as part of evaluation for transplantation. *(Level of Evidence: C)***

Class III

1. **Angina in patients who prefer to avoid revascularization even though it might be appropriate. *(Level of Evidence: C)***
2. **Angina in patients who are not candidates for coronary revascularization or in whom revascularization is not likely to improve quality or duration of life. *(Level of Evidence: C)***
3. **As a screening test for CAD in asymptomatic patients. *(Level of Evidence: C)***
4. **After coronary artery bypass grafting (CABG) or angioplasty when there is no evidence of ischemia on noninvasive testing, unless there is informed consent for research purposes. *(Level of Evidence: C)***
5. **Coronary calcification on fluoroscopy, electron beam computed tomography, or other screening tests without criteria listed above. *(Level of Evidence: C)***

2. Treatment of Patients With Nonspecific Chest Pain

Chest pain syndromes that are not characteristic of angina have been previously called noncardiac, atypical, or angiographically negative chest pain, as well as chest pain of undetermined origin. Chest pain of this type is rarely due to myocardial ischemia, but when it is, less common causes of ischemia, such as variant angina, cocaine abuse, and syndrome X should be suspected. Other cardiac causes of nonspecific chest pain include mitral valve prolapse, myocarditis, pericarditis, and aortic dissection. Noncardiac causes include costochondritis and esophageal disorders. The latter has been implicated as a cause of nonspecific chest pain in 25% of patients. Noninvasive testing should be performed in patients with cardiovascular risk factors and those in whom a noncardiac cause has been excluded or unlikely.

Recommendations for Coronary Angiography in Patients With Nonspecific Chest Pain

Class I

High-risk findings on noninvasive testing. *(Level of Evidence: B)*

Class IIa

None.

Class IIb

Patients with recurrent hospitalizations for chest pain who have abnormal (but not high-risk) or equivocal findings on noninvasive testing. *(Level of Evidence: B)*

Class III

All other patients with nonspecific chest pain. *(Level of Evidence: C)*

3. Unstable Angina

The 1994 "Clinical Practice Guideline for Unstable Angina" (Agency for Health Care Policy and Research and the National Heart, Lung, and Blood Institute) is the basis for the recommendations in this section. Risk stratification of patients with unstable angina is outlined in Table 2. The guidelines recommend outpatient management for those judged to be at low risk at presentation. This group should

TABLE 2. Short-Term Risk of Death or Nonfatal MI in Patients With Unstable Angina

High Risk	Intermediate Risk	Low Risk
≥1 of the following features must be present:	No high-risk feature but must have any of the following features:	No high- or intermediate-risk feature but may have any of the following features:
Prolonged ongoing (>20 min) pain at rest	Prolonged (>20 min) angina at rest, now resolved, with moderate or high likelihood of CAD	Increased frequency, severity, or duration of angina
Pulmonary edema, most likely related to ischemia	Angina at rest (>20 min or relieved with rest or sublingual nitroglycerin)	Angina provoked at a lower threshold
Angina at rest with dynamic ST changes ≥1 mm	Nocturnal angina	New-onset angina with onset 2 wk to 2 mo before presentation
Angina with new or worsening MR murmur	Angina with dynamic T-wave changes	Normal or unchanged ECG
Angina with S_3 or new/worsening rales	New-onset CCS class III or IV angina in the past 2 weeks with moderate or high likelihood of CAD	
Angina with hypotension	Pathological Q waves or resting ST depression ≤1 mm in multiple lead groups (anterior, inferior, lateral)	
	Age >65 y	

MR indicates mitral regurgitation.

Note: Estimation of short-term risk of death or nonfatal MI in unstable angina is a complex, multivariable problem that cannot be fully specified in a table such as this. Therefore, this table is meant to offer general guidance and illustration rather than rigid algorithms. In addition, more recent studies have shown that elevated serum troponin levels are associated with intermediate or high risk.

From Braunwald E, Mark DB, Jones RH, et al. *Unstable Angina: Diagnosis and Management.* 86th ed. Rockville, MD: US Dept of Health and Human Services, Agency for Health Care Policy and Research; 1994. AHCPR publication 94-0602.

undergo noninvasive testing; patients with high-risk criteria for adverse outcome as shown in Table 1 are then candidates for coronary angiography. Patients with unstable angina who are thought to be at intermediate or high risk for death or nonfatal MI at presentation should be admitted to the hospital for intensive medical treatment. Emergency or urgent cardiac catheterization should be performed and/or intra-aortic counterpulsation should be instituted in patients who do not respond after 1 hour of aggressive therapy or in those who have recurrence of symptoms after initial stabilization and are thus considered refractory. For patients whose condition stabilizes after initial treatment, either an "early invasive" or "early conservative" strategy may be undertaken. With the early invasive strategy, all hospitalized patients without contraindications receive elective cardiac catheterization within 48 hours. With the early conservative strategy, only patients with high-risk indications (prior revascularization, congestive heart failure (CHF), LVEF <0.50, malignant ventricular arrhythmia, persistent or recurrent ischemic pain, and/or functional study indicating high risk) are referred for cardiac catheterization. The committee believes that an early invasive strategy with early coronary angiography is useful and effective, although probably better after 24 hours of aggressive medical management, including aspirin and heparin if the clinical situation allows. Other candidates for elective catheterization include patients with significant mitral regurgitation, aortic stenosis, or hypertrophic cardiomyopathy.

Patients with variant angina may present with unstable chest pain and acute ECG changes. Coronary angiography is often performed in these patients to establish a diagnosis and to exclude fixed obstructive disease that might require revascularization.

Recommendations for Coronary Angiography in Unstable Coronary Syndromes

Class I

1. **High or intermediate risk for adverse outcome in patients with unstable angina (Table 2) refractory to initial adequate medical therapy, or recurrent symptoms after initial stabilization. Emergent catheterization is recommended.** ***(Level of Evidence: B)***
2. **High risk for adverse outcome in patients with unstable angina (Table 2). Urgent catheterization is recommended.** ***(Level of Evidence: B)***
3. **High- or intermediate-risk unstable angina that stabilizes after initial treatment.** ***(Level of Evidence: A)***
4. **Initially low short-term–risk unstable angina (Table 2) that is subsequently high risk on noninvasive testing (Table 1).** ***(Level of Evidence: B)***
5. **Suspected Prinzmetal variant angina.** ***(Level of Evidence: C)***

Class IIa

None.

Class IIb

Low short-term–risk unstable angina, without high-risk criteria on noninvasive testing. ***(Level of Evidence: C)***

Class III

1. **Recurrent chest discomfort suggestive of unstable angina but without objective signs of ischemia and with a normal coronary angiogram during the past 5 years.** ***(Level of Evidence: C)***
2. **Unstable angina in patients who are not candidates for coronary revascularization or in patients for whom coronary revascularization will not improve the quality or duration of life. (*Level of Evidence: C)***

4. Recurrence of Ischemia After Revascularization

Most revascularization procedures are performed when there is likely to be a survival benefit for patients with a high risk for adverse outcome or when there is a large amount of myocardium at risk. Therefore, postrevascularization recurrence of ischemia in these patients is generally managed aggressively.

Acute coronary closure complicates 2% to 11% of percutaneous coronary interventions and is associated with a high incidence of complications. Coronary angiography is generally performed emergently on any patient with suspected abrupt closure with the intent to repeat intervention, if possible.

Recurrence of stenosis after percutaneous transluminal coronary intervention is still the major limitation to long-term clinical success of the procedure. A distinction should be made between clinical and angiographic restenosis. Clinical, ie, symptomatic restenosis, should be suspected in patients who present with recurrent angina within 9 months of a catheter-based revascularization procedure. Coronary angiography is generally performed in symptomatic patients with suspected restenosis to reassess anatomy and repeat revascularization as needed. Although coronary angiography may reveal angiographic restenosis in asymptomatic postangioplasty patients who have a positive stress test result, these patients generally have a good outcome, and asymptomatic angiographic restenosis may regress. Therefore, the committee recommends against routine noninvasive evaluation of asymptomatic patients after angioplasty. When noninvasive testing is done in asymptomatic patients and reveals high-risk markers for adverse outcome, coronary angiography is indicated.

Patients with prior coronary artery bypass surgery who develop postoperative angina represent an important subset of patients who require aggressive therapy. Graft obstruction within 1 to 2 months of surgery is generally related to a technical problem and can often be treated with percutaneous techniques as can graft disease within the first year. There are no data that compare outcomes in patients with late postoperative angina or ischemia who are treated medically with those treated with revascularization techniques. Most bypass patients who are suitable candidates for further revascularization and who have noninvasive evidence of high risk for adverse outcome are appropriate subjects for coronary angiography. Those who are symptomatic but deemed to be low risk by noninvasive testing can be treated medically before angiography is considered.

Recommendations for Coronary Angiography in Patients With Postrevascularization Ischemia

Class I

1. **Suspected abrupt closure or subacute stent thrombosis after percutaneous revascularization. *(Level of Evidence: B)***
2. **Recurrent angina or high-risk criteria on noninvasive evaluation (Table 1) within 9 months of percutaneous revascularization. *(Level of Evidence: C)***

Class IIa

1. **Recurrent symptomatic ischemia within 12 months of coronary artery bypass graft. *(Level of Evidence: B)***
2. **Noninvasive evidence of high-risk criteria at any time postoperatively. *(Level of Evidence: B)***
3. **Recurrent angina inadequately controlled by medical means after revascularization. *(Level of Evidence: C)***

Class IIb

1. **Asymptomatic post-PTCA patient suspected of having restenosis within the first months after angioplasty because of an abnormal noninvasive test result but without noninvasive high-risk criteria. *(Level of Evidence: B)***
2. **Recurrent angina without high-risk criteria on noninvasive testing occurring >1 year postoperatively. *(Level of Evidence: C)***
3. **Asymptomatic postbypass patient in whom a deterioration in serial noninvasive testing has been documented but who is not at high risk on noninvasive testing. *(Level of Evidence: C)***

Class III

1. **Symptoms in a postbypass patient who is not a candidate for repeat revascularization. *(Level of Evidence: C)***
2. **Routine angiography in asymptomatic patients after percutaneous transluminal coronary angioplasty (PTCA) or other surgery, unless as part of an approved research protocol. *(Level of Evidence: C)***

5. Acute MI

Although coronary angiography may be performed during or after MI solely for diagnostic purposes, the vast majority of studies are done to evaluate the patient for a percutaneous or surgical revascularization procedure. Therefore, the appropriateness of performing coronary angiography after MI is, by necessity, linked to the efficacy of these revascularization procedures as measured by improved outcome for the patient. Guidelines covering PTCA, coronary artery bypass graft surgery, and management of acute MI have been published by the ACC/AHA Task Force on the Assessment of Diagnostic and Therapeutic Procedures within the past 5 years and include recommendations relevant to the use of coronary angiography.

In practical terms, the use of coronary angiography in patients with acute MI is considered during 3 separate time periods. The first is related to the use of coronary angiography during recognition and treatment of MI in the emergency department. It is only applicable to patients who present with an acute evolving MI within a time frame when reperfusion therapy will likely be beneficial. It is useful to stratify these patients by the presence or absence of ST-segment elevation on the ECG. Because clinical outcomes, especially with thrombolysis, are similar, the committee included in the group with ST-segment elevation patients with typical ischemic chest pain and a new or presumed new left bundle-branch block (BBB) obscuring the ECG diagnosis of MI. In the

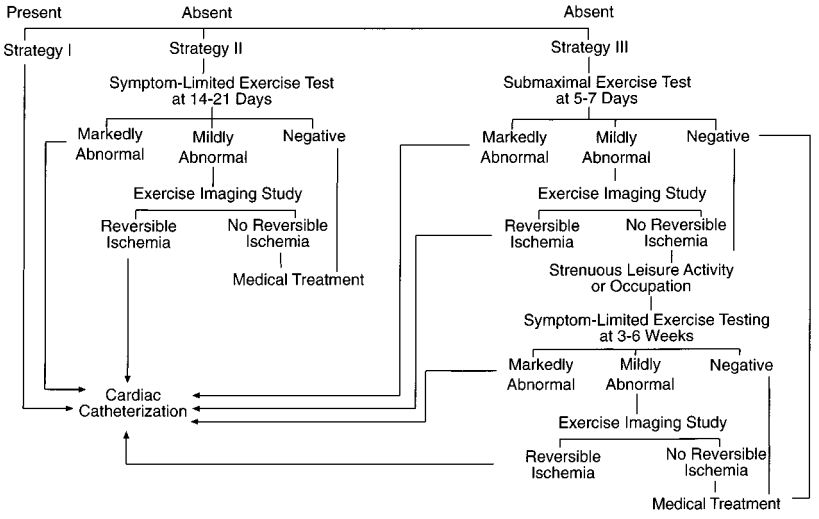

Figure 3. Strategies for risk stratification soon after MI. Clinical indication of high risk at predischarge. If patients are at high risk for ischemic events on the basis of clinical criteria, they should undergo invasive evaluation to determine if they are candidates for coronary revascularization procedures (Strategy I). For patients initially deemed to be at low risk at time of discharge after MI, 2 strategies for performing exercise testing can be used. One is a symptom-limited test at 14 to 21 days (Strategy II). If the patient is taking digoxin or if baseline ECG precludes accurate interpretation of ST-segment changes (eg, baseline left bundle-branch block or left ventricular hypertrophy), then an initial exercise imaging study can be performed. Results of exercise testing should be stratified to determine need for additional invasive or exercise perfusion studies. A third strategy is to perform a submaximal exercise test at 5 to 7 days after MI or just before hospital discharge. The exercise test results could be stratified using the guidelines in Strategy I. If exercise test studies are negative, a second symptom-limited exercise test could be repeated at 3 to 6 weeks for patients undergoing vigorous activity during leisure or at work. From Ryan TJ, Anderson JL, Antman EM. ACC/AHA guidelines for management of acute myocardial infarction: a report of the ACC/AHA Task Force on Practice Guidelines. *J Am Coll Cardiol.* 1996;28:1328–1428.

presence of ongoing ischemic chest pain and ST-segment elevation (or left BBB), the clinician must quickly weigh the risks and benefits of reperfusion therapy and determine whether to use thrombolysis or mechanical techniques. Patients with ongoing ischemic chest pain but without ST-segment elevation are a distinct group with different indications for coronary angiography compared with those with ST-segment elevation.

The second time period relates to the use of coronary angiography during the hospital-management phase, after completion of reperfusion therapy, if used, or immediately if reperfusion therapy is not used. Throughout the remainder of the *hospital-management phase,* the clinician is mainly concerned with treatment of various complications, such as arrhythmia, heart failure, or recurrent ischemia that may develop.

The final time period is defined not by a specific time but rather by evaluations to determine the risk of future morbid events and the need for additional therapies. In these guidelines, the *risk stratification phase* refers to testing specifically performed in the patient with MI to determine if high-risk indicators are present.

For a broad discussion of management and risk stratification (Figure 3) of patients with acute MI, the reader is referred to the full report of this committee and the 1996 "ACC/AHA Guidelines for the Management of Acute Myocardial Infarction."

Recommendations for Coronary Angiography During the Initial Management of Acute MI (MI Suspected and ST Elevation or BBB Present)

Coronary Angiography Coupled With the Intent to Perform Primary PTCA

Class I

1. **As an alternative to thrombolytic therapy in patients who can undergo angioplasty of the infarct artery within 12 hours of the onset of symptoms or beyond 12 hours if ischemic symptoms persist, *if performed in a timely fashion* by individuals skilled in the procedure† and supported by experienced personnel in an appropriate laboratory environment.‡ (Level of Evidence: A)***

   ***Performance standard: within 90 minutes.**

   †Individuals who perform >75 PTCA procedures per year.

   ‡Centers that perform >200 PTCA procedures per year and have cardiac surgical capability.

2. **In patients who are within 36 hours of an acute ST elevation/Q-wave or new LBBB MI who develop cardiogenic shock, are <75 years of age, and in whom revascularization can be performed within 18 hours of the onset of shock.**

Class IIa

As a reperfusion strategy in patients who are candidates for reperfusion but who have a contraindication to fibrinolytic therapy, if angioplasty can be performed as outlined above in class I. *(Level of Evidence: C)*

Class III

1. **In patients who are beyond 12 hours from onset of symptoms and who have no evidence of myocardial ischemia. *(Level of Evidence: A)***
2. **In patients who are eligible for thrombolytic therapy and are undergoing primary angioplasty by an unskilled operator in a laboratory that does not have surgical capability. *(Level of Evidence: B)***

Recommendations for Early Coronary Angiography in the Patient With Suspected MI (ST-Segment Elevation or BBB Present) Who Has Not Undergone Primary PTCA

Class I

None.

Class IIa

Cardiogenic shock or persistent hemodynamic instability. *(Level of Evidence: B)*

Class IIb

1. **Evolving large or anterior infarction after thrombolytic treatment when it is believed that reperfusion has not occurred and rescue PTCA is planned. *(Level of Evidence: B)***
2. **Marginal hemodynamic status but not actual cardiogenic shock when standard management (optimizing filling pressures) does not result in improvement. *(Level of Evidence: C)***

Class III

1. **In patients who have received thrombolytic therapy and have no symptoms of ischemia. *(Level of Evidence: A)***
2. **Routine use of angiography and subsequent PTCA within 24 hours of administration of thrombolytic agents. *(Level of Evidence: A)***

Recommendations for Early Coronary Angiography in Acute MI (MI Suspected but No ST-Segment Elevation)

Class I

1. **Persistent or recurrent (stuttering) episodes of symptomatic ischemia, spontaneous or induced, with or without associated ECG changes. *(Level of Evidence: A)***
2. **The presence of shock, severe pulmonary congestion, or continuing hypotension. *(Level of Evidence: B)***

Class II

None.

Class III

None.

Recommendations for Coronary Angiography During the Hospital-Management Phase (Patients With Q-Wave and Non–Q-Wave Infarction)

Class I

1. **Spontaneous myocardial ischemia or myocardial ischemia provoked by minimal exertion, during recovery from infarction. *(Level of Evidence: C)***
2. **Before definitive therapy of a mechanical complication of infarction such as acute mitral regurgitation, ventricular septal defect, pseudoaneurysm, or left ventricular aneurysm. *(Level of Evidence: C)***
3. **Persistent hemodynamic instability. *(Level of Evidence: B)***

Class IIa

1. **When MI is suspected to have occurred by a mechanism other than thrombotic occlusion at an atherosclerotic plaque (eg, coronary embolism, arteritis, trauma, certain metabolic or hematologic diseases, or coronary spasm). *(Level of Evidence: C)***

TABLE 3. Exercise Test Predictors of Adverse Outcome in Postinfarction Patients

1.	Ischemic ST-segment depression ≥1 mm, particularly if accompanied by symptoms, at low level of exercise or in the presence of controlled heart failure.
2.	Functional capacity <5 METS.
3.	Inadequate blood pressure response (peak systolic blood pressure <110 mm Hg or <30 mm Hg increase from resting level).

From 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.

2. **Survivors of acute MI with LVEF ≤0.40, CHF, prior revascularization, or malignant ventricular arrhythmias. *(Level of Evidence: C)***
3. **Clinical heart failure during the acute episode, but subsequent demonstration of preserved left ventricular function (LVEF >0.40). *(Level of Evidence: C)***

Class IIb

1. **Coronary angiography to find a persistently occluded infarct-related artery in an attempt to revascularize that artery (open artery hypothesis). *(Level of Evidence: C)***
2. **Coronary angiography performed without other risk stratification to identify the presence of left main or 3-vessel disease. *(Level of Evidence: C)***
3. **All patients after a non–Q-wave MI. *(Level of Evidence: C)***
4. **Recurrent ventricular tachycardia and/or ventricular fibrillation, despite antiarrhythmic therapy, without evidence of ongoing myocardial ischemia. *(Level of Evidence: C)***

Class III

Patients who are not candidates for or who refuse coronary revascularization. *(Level of Evidence: C)*

Recommendations for Coronary Angiography During the Risk-Stratification Phase (Patients With All Types of MI)

Class I

Ischemia at low levels of exercise with ECG changes (≥1-mm ST-segment depression or other predictors of adverse outcome) (Table 3) and/or imaging abnormalities. *(Level of Evidence: B)*

Class IIa

1. **Clinically significant CHF during the hospital course. *(Level of Evidence: C)***
2. **Inability to perform an exercise test with LVEF ≤0.45. *(Level of Evidence: C)***

Class IIb

1. **Ischemia occurring at high levels of exercise. *(Level of Evidence: C)***

2. **Non–Q-wave MI in a patient who is an appropriate candidate for a revascularization procedure.** ***(Level of Evidence: C)***
3. **Need to return to an unusually active form of employment.** ***(Level of Evidence: C)***
4. **Remote history of MI without evidence of CHF during the current event and without evidence of inducible ischemia.** ***(Level of Evidence: C)***
5. **Recurrent ventricular tachycardia, fibrillation, or both, despite antiarrhythmic therapy, without ongoing myocardial ischemia.** ***(Level of Evidence: C)***

Class III

Patients who are not candidates for or who refuse coronary revascularization. ***(Level of Evidence: C)***

6. Perioperative Coronary Angiography for Patients Undergoing Noncardiac Surgery

The perioperative evaluation of patients undergoing noncardiac surgery was recently detailed in the "ACC/AHA Guidelines for Perioperative Cardiovascular Evaluation for Noncardiac Surgery." This document outlines a comprehensive approach to perioperative risk assessment that stresses the patient's prior clinical indicators of coronary heart disease, functional status, type of noncardiac surgery, and the role of selected preoperative stress testing in patients thought to be at intermediate or high risk for major perioperative coronary events.

Generally, in patients who are being considered for noncardiac surgery, the indications for coronary angiography should be identical to those outlined in this document. However, the presentation for noncardiac surgery, its potential urgency, the level of cardiovascular stress anticipated, and the patient's general condition all play critical roles in determining the most logical sequence of events for a given patient.

Recommendations for Coronary Angiography in Perioperative Evaluation Before (or After) Noncardiac Surgery

Class I: Patients with suspected or known CAD

1. **Evidence for high risk of adverse outcome based on noninvasive test results (Table 1).** ***(Level of Evidence: C)***
2. **Angina unresponsive to adequate medical therapy.** ***(Level of Evidence: C)***
3. **Unstable angina, particularly when facing intermediate* or high-risk* noncardiac surgery.** ***(Level of Evidence: C)***
4. **Equivocal noninvasive test result in a high-clinical-risk† patient undergoing high-risk* surgery.** ***(Level of Evidence: C)***

Class IIa

1. **Multiple intermediate-clinical-risk markers† and planned vascular surgery.** ***(Level of Evidence: B)***
2. **Ischemia on noninvasive testing but without high-risk criteria (Table** 1). ***(Level of Evidence: B)***
3. **Equivocal noninvasive test result in intermediate-clinical-risk† patient undergoing high-risk* noncardiac surgery.** ***(Level of Evidence: C)***
4. **Urgent noncardiac surgery while convalescing from acute MI.** ***(Level of Evidence: C)***

Class IIb

1. **Perioperative MI.** ***(Level of Evidence: B)***
2. **Medically stabilized class III or IV angina and planned low-risk or minor* surgery.** ***(Level of Evidence: C)***

Class III

1. **Low-risk* noncardiac surgery, with known CAD and no high-risk results on noninvasive testing.** ***(Level of Evidence: B)***
2. **Asymptomatic after coronary revascularization with excellent exercise capacity (≥7 METs).** ***(Level of Evidence: C)***
3. **Mild stable angina with good left ventricular function and no high-risk noninvasive test results.** ***(Level of Evidence: B)***
4. **Noncandidate for coronary revascularization owing to concomitant medical illness, severe left ventricular dysfunction (eg, LVEF <0.20), or refusal to consider revascularization.** ***(Level of Evidence: C)***
5. **Candidate for liver, lung, or renal transplant ≥40 years old as part of evaluation for transplantation, unless noninvasive testing reveals high risk for adverse outcome.** ***(Level of Evidence: C)***

***Cardiac risk according to type of noncardiac surgery. High risk: emergent major operations, aortic and major vascular, peripheral vascular, anticipated prolonged surgical procedures associated with large fluid shifts and/or blood loss; intermediate risk: carotid endarterectomy, major head and neck, intraperitoneal and/or intrathoracic, orthopedic surgery, prostate surgery; low risk: endoscopic procedures, superficial procedures, cataract surgery, breast surgery.**

†Cardiac risk according to clinical predictors of perioperative death, MI, or CHF. High clinical risk: unstable angina, recent MI and evidence of important residual ischemic risk, decompensated CHF, high degree of atrioventricular block, symptomatic ventricular arrhythmias with known structural heart disease, severe symptomatic valvular heart disease, multiple intermediate risk markers such as prior MI, CHF, and diabetes; intermediate clinical risk: CCS class I or II angina, prior MI by history or ECG, compensated or prior CHF, diabetes mellitus.

B. Valvular Heart Disease

In all forms of valvular heart disease, the presence of significant coronary disease worsens prognosis. Most practitioners feel compelled to assess coronary anatomy before valve surgery and to bypass significant obstructions during surgery with the hope of avoiding late reoperation. Although there are no large clinical trials to prove its value, angiography seems to play an important role in the preoperative evaluation of patients with valvular heart disease.

That role continues to evolve. All patients with chest pain or noninvasive evidence of coronary disease should undergo coronary angiography. It still seems prudent to perform coronary angiography in patients who are at increased risk for coronary disease because of age or other risk factors.

Recommendations for Use of Coronary Angiography in Patients With Valvular Heart Disease

Class I

1. **Before valve surgery or balloon valvotomy in an adult with chest discomfort, ischemia by noninvasive imaging, or both.** ***(Level of Evidence: B)***
2. **Before valve surgery in an adult free of chest pain but of substantial age and/or with multiple risk factors for coronary disease.** ***(Level of Evidence: C)***
3. **Infective endocarditis with evidence of coronary embolization.** ***(Level of Evidence: C)***

Class IIa

None.

Class IIb

During left-heart catheterization performed for hemodynamic evaluation before aortic or mitral valve surgery in patients without preexisting evidence of coronary disease, multiple CAD risk factors, or advanced age. ***(Level of Evidence: C)***

Class III

1. **Before cardiac surgery for infective endocarditis when there are no risk factors for coronary disease and no evidence of coronary embolization.** ***(Level of Evidence: C)***
2. **In asymptomatic patients when cardiac surgery is not being considered.** ***(Level of Evidence: C)***
3. **Before cardiac surgery when preoperative hemodynamic assessment by catheterization is unnecessary, and there is neither preexisting evidence of coronary disease nor risk factors for CAD.** ***(Level of Evidence: C)***

C. Congenital Heart Disease

Although there are no large trials to support its use, coronary angiography is performed in congenital heart disease for 2 broad categorical indications. The first is to assess the hemodynamic impact of congenital coronary lesions. The second is to assess the presence of coronary anomalies, which by themselves may be innocent but whose presence, if unrecognized, may lead to coronary injury during correction of other congenital heart lesions.

In some cases, surgical correction is performed when the patient is older and risk of coronary disease increases. It seems prudent to perform coronary arteriography in patients being considered for repair of congenital heart disease if angina, ischemia on noninvasive testing, or multiple coronary risk factors are present.

Recommendations for Use of Coronary Angiography in Patients With Congenital Heart Disease

Class I

1. **Before surgical correction of congenital heart disease when chest discomfort or noninvasive evidence is suggestive of associated CAD.** ***(Level of Evidence: C)***
2. **Before surgical correction of suspected congenital coronary anomalies such as congenital coronary artery stenosis, coronary arteriovenous fistula, and anomalous origin of left coronary artery.** ***(Level of Evidence: C)***
3. **Forms of congenital heart disease frequently associated with coronary artery anomalies that may complicate surgical management.** ***(Level of Evidence: C)***
4. **Unexplained cardiac arrest in a young patient.** ***(Level of Evidence: B)***

Class IIa

Before corrective open heart surgery for congenital heart disease in an adult whose risk profile increases the likelihood of coexisting coronary disease. ***(Level of Evidence: C)***

Class IIb

During left-heart catheterization for hemodynamic assessment of congenital heart disease in an adult in whom the risk of coronary disease is not high. ***(Level of Evidence: C)***

Class III

In the routine evaluation of congenital heart disease in asymptomatic patients for whom heart surgery is not planned. ***(Level of Evidence: C)***

D. Congestive Heart Failure

Coronary angiography should be strongly considered for patients with systolic left ventricular dysfunction and a strong suspicion of hibernating myocardium based on the findings of noninvasive evaluation. In patients with normal systolic function but otherwise unexplained episodes of acute pulmonary edema, coronary angiography may be necessary to rule out ischemically related systolic and/or diastolic left ventricular dysfunction.

Recommendations for Use of Coronary Angiography in Patients With CHF

Class I

1. **CHF due to systolic dysfunction with angina or with regional wall motion abnormalities and/or scintigraphic evidence of reversible myocardial ischemia when revascularization is being considered.** ***(Level of Evidence: B)***
2. **Before cardiac transplantation.** ***(Level of Evidence: C)***
3. **CHF secondary to postinfarction ventricular aneurysm or other mechanical complications of MI.** ***(Level of Evidence: C)***

Class IIa

1. **Systolic dysfunction with unexplained cause despite noninvasive testing.** ***(Level of Evidence: C)***
2. **Normal systolic function, but episodic heart failure raises suspicion of ischemically mediated left ventricular dysfunction.** ***(Level of Evidence: C)***

Class III

CHF with previous coronary angiograms showing normal coronary arteries, with no new evidence to suggest ischemic heart disease. ***(Level of Evidence: C)***

E. Other Conditions

Recommendations for Use of Coronary Angiography in Other Conditions

Class I

1. **Diseases affecting the aorta when knowledge of the presence or extent of coronary artery involvement is necessary for management (eg, aortic dissection or aneurysm with known coronary disease).** ***(Level of Evidence: B)***
2. **Hypertrophic cardiomyopathy with angina despite medical therapy when knowledge of coronary anatomy might affect therapy.** ***(Level of Evidence: C)***
3. **Hypertrophic cardiomyopathy with angina when heart surgery is planned.** ***(Level of Evidence: B)***

Class IIa

1. **High risk for coronary disease when other cardiac surgical procedures are planned (eg, pericardiectomy or removal of chronic pulmonary emboli).** ***(Level of Evidence: C)***
2. **Prospective immediate cardiac transplant donors whose risk profile increases the likelihood of coronary disease.** ***(Level of Evidence: B)***
3. **Asymptomatic patients with Kawasaki disease who have coronary artery aneurysms on echocardiography.** ***(Level of Evidence: B)***
4. **Before surgery for aortic aneurysm/dissection in patients without known coronary disease.**
5. **Recent blunt chest trauma and suspicion of acute MI, without evidence of preexisting CAD.** ***(Level of Evidence: C)***

Appendix A

Pharmacological Assessment of Coronary Spasm

Of the tests available to demonstrate coronary spasm, provocation by methylergonovine maleate, acetylcholine, or hyperventilation is the most useful. The methylergonovine provocative test is the most reliable test for coronary spasm in patients with Prinzmetal variant angina. To ensure a valid test, nitrates and calcium antagonists must be withdrawn for ≥48 hours before testing. Methylergonovine should be administered to patients with suspected Prinzmetal angina by an experienced operator, preferably in a cardiac catheterization laboratory with full resuscitative capabilities.

Alternatively, intracoronary acetylcholine can be used as a provocative test for spasm. Its effectiveness is comparable to methylergonovine. In patients with ≥1 episode of variant angina per day, the hyperventilation provocative test is nearly as effective as methylergonovine in causing vasospasm. The end point of a pharmacological provocative test is focal coronary spasm, which can be reversed with intracoronary nitroglycerin.

In patients with ST-segment elevation during chest pain and a normal coronary angiogram, provocative tests are usually not necessary because ample clinical evidence is present to confirm the diagnosis of coronary spasm.

Recommendations for Pharmacological Assessment of Coronary Disease 48 Hours After Withdrawal of Coronary Vasodilators

Class I

None.

Class IIa

Recurrent episodes of apparent ischemic cardiac pain at rest in a patient found to have a normal or mildly abnormal coronary angiogram and in whom there have been no clinical observations that substantiate the diagnosis of variant angina, ie, ST-segment elevation during pain. ***(Level of Evidence: C)***

Class IIb

1. **Recurrent episodes of ischemic cardiac pain at rest with associated transient ST-segment elevation in a patient subsequently found to have a normal or mildly abnormal coronary angiogram in whom medical therapy has been unsuccessful in controlling symptoms of ischemia.** ***(Level of Evidence: C)***
2. **After recovery from sudden cardiac death in a patient subsequently found to have a normal or mildly abnormal coronary angiogram and no other detectable significant cardiac disease.** ***(Level of Evidence: C)***

Class III

1. **Any absolute contraindication to pharmacological challenge, including possible pregnancy, severe hypertension, severe left ventricular dysfunction, moderate to severe aortic stenosis, or high-grade left main coronary stenosis.** ***(Level of Evidence: C)***
2. **Patients with any relative contraindication to pharmacological testing, including uncontrolled or unstable angina, uncontrolled ventricular arrhythmia, recent MI, or severe 3-vessel coronary disease.** ***(Level of Evidence: C)***

Appendix B

Alternative Imaging Modalities

1. Coronary Intravascular Ultrasound

Unlike angiography, which depicts a silhouette of the coronary lumen, intravascular ultrasound portrays the vessel from a tomographic, cross-sectional perspective. This orientation enables direct measurements of luminal dimensions, including minimum and maximum diameter and cross-sectional area. The ability of coronary ultrasound to image the soft tissues within the arterial wall enables characterization of atheroma size, plaque distribution, and lesion composition during diagnostic or therapeutic catheterization.

Recommendations for Coronary Intravascular Ultrasound

Class I

None.

Class IIa

1. **Evaluation of lesion severity at a location difficult to image by angiography in a patient with a positive functional study and a suspected flow-limiting stenosis.** ***(Level of Evidence: C)***
2. **Assessment of a suboptimal angiographic result after coronary intervention.** ***(Level of Evidence: C)***
3. **Diagnosis and management of coronary disease after cardiac transplantation.** ***(Level of Evidence: C)***
4. **Assessment of the adequacy of deployment of the Palmaz-Schatz coronary stent, including the extent of stent apposition**

and determination of the minimum luminal diameter within the stent. ***(Level of Evidence: B)***

Class IIb

1. **Determination of plaque location and circumferential distribution for guidance of directional coronary atherectomy.** ***(Level of Evidence: C)***
2. **Further evaluation of patients with characteristic anginal symptoms and a positive functional study with no focal stenoses or mild CAD on angiography.** ***(Level of Evidence: C)***
3. **Determination of the mechanism of stent restenosis (inadequate expansion versus neointimal proliferation) and to enable selection of appropriate therapy (plaque ablation versus repeat balloon expansion).** ***(Level of Evidence: C)***
4. **Preinterventional assessment of lesional characteristics as a means to select an optimal revascularization device.** ***(Level of Evidence: C)***

Class III

When angiographic diagnosis is clear and no interventional treatment is planned.

2. Intracoronary Doppler Ultrasound

The development of small intracoronary devices that incorporate a Doppler flow transducer has made feasible the physiological assessment of coronary blood flow in vivo during diagnostic or therapeutic catheterization. Doppler flow probes can be used to evaluate ambiguous lesions and determine the success of coronary interventions in restoring normal flow reserve.

Recommendations for Intracoronary Doppler Ultrasound

Class I

None.

Class IIa

Assessment of the physiological effects of intermediate coronary stenoses (30% to 70% luminal narrowing) in patients with anginal symptoms. Doppler velocimetry may also be useful as an alternative to performing a noninvasive functional study to determine whether an intervention is warranted for intermediate lesions (or when the functional study is ambiguous). ***(Level of Evidence: C)***

Class IIb

1. **Evaluation of the success of percutaneous coronary revascularization in restoring flow reserve and to predict the risk of restenosis.** ***(Level of Evidence: C)***
2. **After cardiac transplantation, diagnosis of impaired coronary flow reserve in patients with anginal symptoms but no apparent angiographic culprit lesion.** ***(Level of Evidence: C)***
3. **Assessment of the severity of coronary flow abnormalities in patients with anginal symptoms and a positive noninvasive functional study but no apparent angiographic lesion.** ***(Level of Evidence: C)***

Class III

Routine assessment of the severity of angiographic disease in patients with a positive noninvasive functional study. ***(Level of Evidence: C)***

3. Coronary Angioscopy

Coronary angioscopy uses visible light conducted through fiberoptic filaments to provide direct visual assessment of surface characteristics and intraluminal morphology in vivo. The images appear in color on a television monitor, which enables examination of the hue of the target lesion and associated plaques. Although difficult to use, angioscopy allows differentiation of platelet-rich thrombus from fibrin-rich thrombus, and it may provide evidence of atheroma rupture, intraplaque hemorrhage, and/or coronary dissection.

Recommendations for Coronary Angioscopy

Class I

None.

Class II

None.

Class III

Coronary angioscopy should be considered a research tool for which there are no established clinical indications.

4. Fractional Flow Reserve

Pressure gradients across coronary stenosis have been shown to occur in the presence of hemodynamically important stenoses. More recently, it has been demonstrated that the ratio of pressure proximal and distal to stenosis after maximal vasodilation or fractional flow reserve correlates with Doppler flow velocity measurements, exercise testing, and positron emission tomography scanning. This is a currently emerging technique to assess coronary stenosis and, as such, no specific recommendations for its use can be made at this time.

KEY WORDS: AHA Scientific Statements ■ angiography ■ coronary disease ■ angina ■ myocardial infarction