

Special Article

Guidelines for Perioperative Cardiovascular Evaluation for Noncardiac Surgery: An Abridged Version of the Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

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Purpose of These Guidelines.—These guidelines are intended for physicians involved in the preoperative, operative, and postoperative care of patients undergoing noncardiac surgery. They provide a framework for considering cardiac risk of noncardiac surgery in various patient and operative situations. They strive to incorporate the current information on perioperative risk and how this knowledge can be used to treat individual patients. The methods used to develop these guidelines are described in the Appendix.

For accompanying editorial, see page 583

General Approach.—Successful perioperative assessment and treatment of cardiac patients who are undergoing noncardiac surgery necessitate careful teamwork and communication among patient, primary-care physician, anesthesiologist, surgeon, and the medical consultant. In general, indications for further cardiac testing and treatments are the same as those in the nonoperative setting, but their timing depends on such factors as the urgency of noncardiac surgery, the patient's risk factors, and specific surgical considerations. Coronary revascularization before noncardiac surgery to enable the patient to "get through" the noncardiac procedure is appropriate only for a small subset of very high-risk patients. Preoperative testing should be limited to circumstances in which the results will affect patient treatment and outcomes. A conservative approach to the use of expensive tests and treatments is recommended.

Preoperative Clinical Evaluation.—The initial history, physical examination, and electrocardiographic (ECG) assessment should focus on the identification of potentially serious cardiac disorders, including (1) coronary artery disease (CAD) (for example, prior myocardial infarction [MI] or angina pectoris), (2) congestive heart failure (CHF), and (3) electrical instability (symptomatic arrhythmias). In addition to identifying the presence of preexisting manifested heart disease, defining disease severity, stability, and prior treatment is essential. Other factors that help determine cardiac risk include (1) functional capacity, (2) age, (3) comorbid conditions (for example, diabetes mellitus, peripheral vascular disease, renal dysfunction, or chronic pulmonary disease), and (4) type of operation (vascular procedures and prolonged, complicated thoracic, abdominal, and head and neck procedures are considered higher risk).

Further Preoperative Testing to Assess Coronary Risk.—Coronary heart disease is the most frequent cause of perioperative cardiac mortality and morbidity after noncardiac surgery. A common question concerning noncardiac surgery is, Which patients are most likely to benefit from preoperative coronary assessment and treatment? The lack of adequately controlled or randomized clinical trials to determine the optimal evaluation strategy has led to the proposed algorithm based on collected observational data and expert opinion. A stepwise bayesian strategy that relies on assessment of clinical markers, prior coronary evaluation and treatment, functional capacity, and surgery-specific risk is subsequently outlined and correlates with the information

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ACC/AHA = American College of Cardiology/American Heart Association; CABG = coronary artery bypass grafting; CAD = coronary artery disease; CHF = congestive heart failure; ECG = electrocardiographic; LV = left ventricular; MET = metabolic equivalent; MI = myocardial infarction; PTCA = percutaneous transluminal coronary angioplasty

in Tables 1 through 4 and Figure 1, which presents in an algorithm format a framework for determining which patients are candidates for cardiac testing. The clinical predictors of perioperative risk are outlined in Table 1. A validated method for assessing functional capacity is presented in Table 2. The risk of various types of noncardiac surgeries is stratified in Table 3, and the indications for coronary angiography are listed in Table 4. For clarity, categories have been established as "black and white," with the realization that individual patient problems occur in "shades of gray." The clinician must consider several interacting variables and weigh them appropriately. Furthermore, no adequate controlled or randomized clinical trials are available to help define the process.

The following steps correspond to the algorithm presented in Figure 1.

Step 1.—What is the urgency of noncardiac surgery? Often, patient or specific surgical factors dictate an obvious strategy (for example, immediate operation) that may not allow further cardiac evaluation. In such cases, the consultant's best approach may be to make recommendations for perioperative medical management and surveillance. Postoperative risk stratification may be appropriate for some patients who have not had such an assessment.

Step 2.—Has the patient undergone coronary revascularization in the past 5 years? If so and if clinical status has remained stable without recurrent symptoms or signs of ischemia, further cardiac testing is generally unnecessary.

Step 3.—Has the patient undergone coronary evaluation in the past 2 years? If coronary risk was adequately assessed and the findings were favorable, repeated testing is usually unnecessary unless the patient has experienced a change or has new symptoms of coronary ischemia since the previous evaluation.

Step 4.—Does the patient have an unstable coronary syndrome or a major clinical predictor of risk (Table 1)? When elective noncardiac surgery is being considered, the presence of unstable coronary disease, decompensated CHF, symptomatic arrhythmias, or severe valvular heart disease (or some combination of these factors) usually leads to cancellation or delay of operation until the problem has been identified and treated. Examples of unstable coronary syndromes include recent MI with evidence of ischemic risk based on clinical symptoms or noninvasive study, unstable or severe angina, and new or poorly controlled ischemia-mediated CHF. Many patients with these syndromes are referred for coronary angiography for further assessment of therapeutic options.

Step 5.—Does the patient have *intermediate clinical predictors of risk* (Table 1)? The presence or absence of prior MI based on history or electrocardiogram, angina pectoris, compensated or prior CHF, or diabetes mellitus helps further

Table 1.—Clinical Predictors of Increased Perioperative Cardiovascular Risk*

Major

- Unstable coronary syndromes
 - Recent myocardial infarction† with evidence of important ischemic risk based on clinical symptoms or noninvasive study
 - Unstable or severe‡ angina (Canadian class III or IV)§
- Decompensated congestive heart failure
- Significant arrhythmias
 - High-grade atrioventricular block
 - Symptomatic ventricular arrhythmias in the presence of underlying heart disease
 - Supraventricular arrhythmias with uncontrolled ventricular rate
- Severe valvular disease

Intermediate

- Mild angina pectoris (Canadian class I or II)
- Prior myocardial infarction based on history or pathologic waves
- Compensated or prior congestive heart failure
- Diabetes mellitus

Minor

- Advanced age
- Abnormal electrocardiographic findings (left ventricular hypertrophy, left bundle branch block, ST-T abnormalities)
- Rhythm other than sinus (for example, atrial fibrillation)
- Low functional capacity (for example, unable to climb one flight of stairs while carrying a bag of groceries)
- History of stroke
- Uncontrolled systemic hypertension

*Myocardial infarction, congestive heart failure, or death.

†The American College of Cardiology National Database Library defines recent myocardial infarction as greater than 7 days but less than or equal to 1 month (30 days).

‡May include "stable" angina in patients who are unusually sedentary.

§Campeau L. Grading of angina pectoris. *Circulation* 1976; 54:522-523.

stratify clinical risk of perioperative coronary events. Consideration of *functional capacity* and level of *surgery-specific risk* allows a rational approach for identifying those patients most likely to benefit from further noninvasive testing.

Functional Capacity.—Functional capacity can be expressed in metabolic equivalent (MET) levels; the oxygen consumption of a 40-year-old man (weight, 70 kg) in a resting state is 3.5 mL/kg per minute or 1 MET. Multiples of the baseline MET value can be used to express aerobic demands for specific activities. Both perioperative cardiac and long-term risk are increased in patients who are unable to meet a 4-MET demand during most normal daily activities. The Duke Activity Status Index (Table 2) and other activity scales provide the clinician with a relatively uncomplicated set of questions to determine a patient's functional capacity as less than or greater than 4 METs.

Table 2.—Estimated Energy Requirements for Various Activities*

1 MET		4 METs	
↓	Can you take care of yourself? Eat, dress, or use the toilet? Walk indoors around the house? Walk a block or two on level ground at 2-3 mph or 3.2-4.8 km/h? Do light work around the house like dusting or washing dishes?	↓	Climb a flight of stairs or walk up a hill? Walk on level ground at 4 mph or 6.4 km/h? Run a short distance? Do heavy work around the house like scrubbing floors or lifting or moving heavy furniture? Participate in moderate recreational activities like golf, bowling, dancing, doubles tennis, or throwing a baseball or football? Participate in strenuous sports like swimming, singles tennis, football, basketball, or skiing?
4 METs		>10 METs	

*MET = metabolic equivalent; mph = miles per hour.

Adapted from the Duke Activity Status Index (Hlatky MA, Boineau RE, Higginbotham MB, Lee KL, Mark DB, Califf RM, et al. A brief self-administered questionnaire to determine functional capacity [the Duke Activity Status Index]. *Am J Cardiol* 1989; 64:651-654) and AHA Exercise Standards (Fletcher GF, Balady G, Froelicher VF, Hartley LH, Haskell WL, Pollock ML. Exercise standards: a statement for healthcare professionals from the American Heart Association. *Circulation* 1995; 91:580-615).

Surgery-Specific Cardiac Risk.—Surgery-specific cardiac risk (Table 3) of noncardiac surgery is related to two important factors. The first factor is that the type of operation itself may identify a patient with a greater likelihood of underlying heart disease, such as a vascular operation, in which underlying CAD is present in a substantial portion of patients. The second aspect is the degree of hemodynamic stress associated with surgery-specific procedures. Certain operations more predictably result in intraoperative or postoperative alterations in heart rate and blood pressure, fluid shifts, pain, bleeding, clotting tendencies, oxygenation, neurohumoral activation, and other perturbations. The duration and intensity of these coronary and myocardial stressors help estimate the likelihood of perioperative cardiac events. This likelihood is particularly evident in emergency operations in which the risk of cardiac complications is substantially increased.

Examples of noncardiac surgery and associated surgery-specific risks are listed in Table 3. Higher-risk operations include aortic, peripheral vascular, and anticipated prolonged procedures associated with major fluid shifts or blood loss (or both) involving the abdomen, thorax, head, and neck.

Step 6.—Patients without major but with intermediate predictors of clinical risk (Table 1) and with moderate or excellent functional capacity can generally undergo an intermediate-risk operation with little likelihood of perioperative death or MI. Conversely, further noninvasive testing is often considered in patients with poor functional capacity or moderate functional capacity but undergoing higher-risk operations and especially in patients with two or more intermediate predictors (that is, prior MI, prior or compensated CHF, angina, or diabetes mellitus).

Step 7.—Noncardiac surgery is generally safe for patients with neither major nor intermediate predictors of clinical risk (Table 1) and moderate or excellent functional capacity (4 METs or greater). Further testing may be considered on an individual basis for patients without clinical markers but poor functional capacity who are to undergo higher-risk operations, particularly those with several minor clinical predictors of risk who are to undergo vascular surgical treatment.

Step 8.—The results of noninvasive testing can be used to determine further preoperative management. Such management can include intensified medical therapy; cardiac

Table 3.—Cardiac Risk* Stratification for Noncardiac Surgical Procedures

High (reported cardiac risk often >5%)
Emergent major operations, particularly in elderly patients
Aortic and other major vascular operation
Peripheral vascular operation
Anticipated prolonged surgical procedures associated with large fluid shifts or blood loss (or both)
Intermediate (reported cardiac risk generally <5%)
Carotid endarterectomy
Head and neck operation
Intraperitoneal and intrathoracic operation
Orthopedic operation
Prostate operation
Low† (reported cardiac risk generally <1%)
Endoscopic procedures
Superficial procedure
Cataract operation
Breast operation

*Combined incidence of cardiac death and nonfatal myocardial infarction.

†Further preoperative cardiac testing is generally unnecessary.

catheterization, which may lead to coronary revascularization; or cancellation or delay of the elective noncardiac operation. Alternatively, the results may lead to a recommendation to proceed with the operation. In some patients, the risk of intervention or corrective cardiac surgery may be similar to or even exceed that of the proposed noncardiac surgery; however, such intervention may be appropriate if it substantially improves the patient's long-term prognosis.

For some patients, a careful consideration of clinical, surgery-specific, and functional status leads to a decision to proceed to coronary angiography.

Methods of Assessing Cardiac Risk. Resting Left Ventricular Function.—Several studies have shown that a left ventricular (LV) ejection fraction lower than 35% increases the risk of noncardiac surgery. Patients with severe diastolic dysfunction are also at increased risk. The presence of current or poorly controlled CHF is an indication for evaluation of LV function. Possible indications include prior CHF or dyspnea of unknown cause.

Exercise Stress Testing.—Preoperative exercise testing with use of a treadmill or bicycle and ECG analysis with or without echocardiography or nuclear myocardial imaging to identify ischemia provide substantial information about the risk of perioperative MI and cardiac death. Poor functional capacity, particularly that associated with myocardial ischemia, identifies patients with a severalfold increased risk of untoward outcomes. A gradient of increasing ischemic risk is seen in association with degree of functional incapacity, symptoms of ischemia, severity of ischemia (for example, depth, time of onset, and duration of ST-segment depression), and evidence of hemodynamic or electrical instability during or after stress. This gradient also correlates with increasing likelihood of severe and multivessel coronary disease.

Pharmacologic Stress Testing.—For patients who are unable to exercise, selected use of pharmacologic stress testing allows identification of those with heightened risk of coronary events after noncardiac surgery. Dipyridamole or adenosine-thallium stress testing seems to have a high sensitivity and specificity for perioperative coronary events when used in patients with preexistent clinical predictors of risk, particularly angina pectoris, diabetes mellitus, and prior MI as well as prior CHF in patients undergoing vascular surgical treatment. Quantification of the degree of test abnormality may allow a means of establishing a gradient of risk similar to that with exercise testing. Perioperative ischemic events seem to correlate with the magnitude of ischemia such as presence of both ECG evidence of ischemia and thallium redistribution after pharmacologic stress testing or multisegment redistribution, whereas long-term risk of death or MI may be better predicted by the presence of reversible or fixed thallium defects.

Table 4.—Indications for Coronary Angiography* in Perioperative Evaluation Before or After Noncardiac Surgery†

Class I‡ (patients with suspected or proven CAD)
High-risk results during noninvasive testing
Angina pectoris unresponsive to adequate medical therapy
Most patients with unstable angina pectoris
Nondiagnostic or equivocal noninvasive test in a high-risk patient (Table 1) undergoing a high-risk noncardiac surgical procedure (Table 3)
Class II§
Intermediate-risk results during noninvasive testing
Nondiagnostic or equivocal noninvasive test in a lower-risk patient (Table 1) undergoing a high-risk noncardiac surgical procedure (Table 3)
Urgent noncardiac surgery in a patient convalescing from acute MI
Perioperative MI
Class III¶
Low-risk noncardiac surgery (Table 3) in a patient with known CAD and low-risk results on noninvasive testing
Screening for CAD without appropriate noninvasive testing
Asymptomatic after coronary revascularization, with excellent exercise capacity (≥ 7 METs)
Mild stable angina in patients with good LV function, low-risk noninvasive test results
Patient is not a candidate for coronary revascularization because of concomitant medical illness
Technically adequate normal coronary angiographic findings within previous 5 years
Severe LV dysfunction (for example, ejection fraction $< 20\%$) and patient not considered candidate for revascularization procedure
Patient unwilling to consider coronary revascularization procedure

*If results will affect management.

†CAD = coronary artery disease; LV = left ventricular; METs = metabolic equivalents; MI = myocardial infarction.

‡Conditions in which there is evidence for or general agreement that a procedure be performed or a treatment is of benefit.

§Conditions in which there is a divergence of evidence or opinion about the treatment.

¶Conditions in which there is evidence or general agreement that the procedure is unnecessary.

Adapted from ACC/AHA Guidelines for Coronary Angiography.

Pharmacologic stress testing involving echocardiography has emerged as a promising method for stratifying coronary risk before noncardiac surgery. Although the accumulated experience is less than that associated with perfusion imaging, dobutamine echocardiography seems to provide similar information and safety. The opportunity to assess LV and valvular dysfunction simultaneously offers advantages in some patients. As with all stress testing, appropriate identification of patients at medium and high risk and quantification of the degree of test abnormality may enhance predictive accuracy.

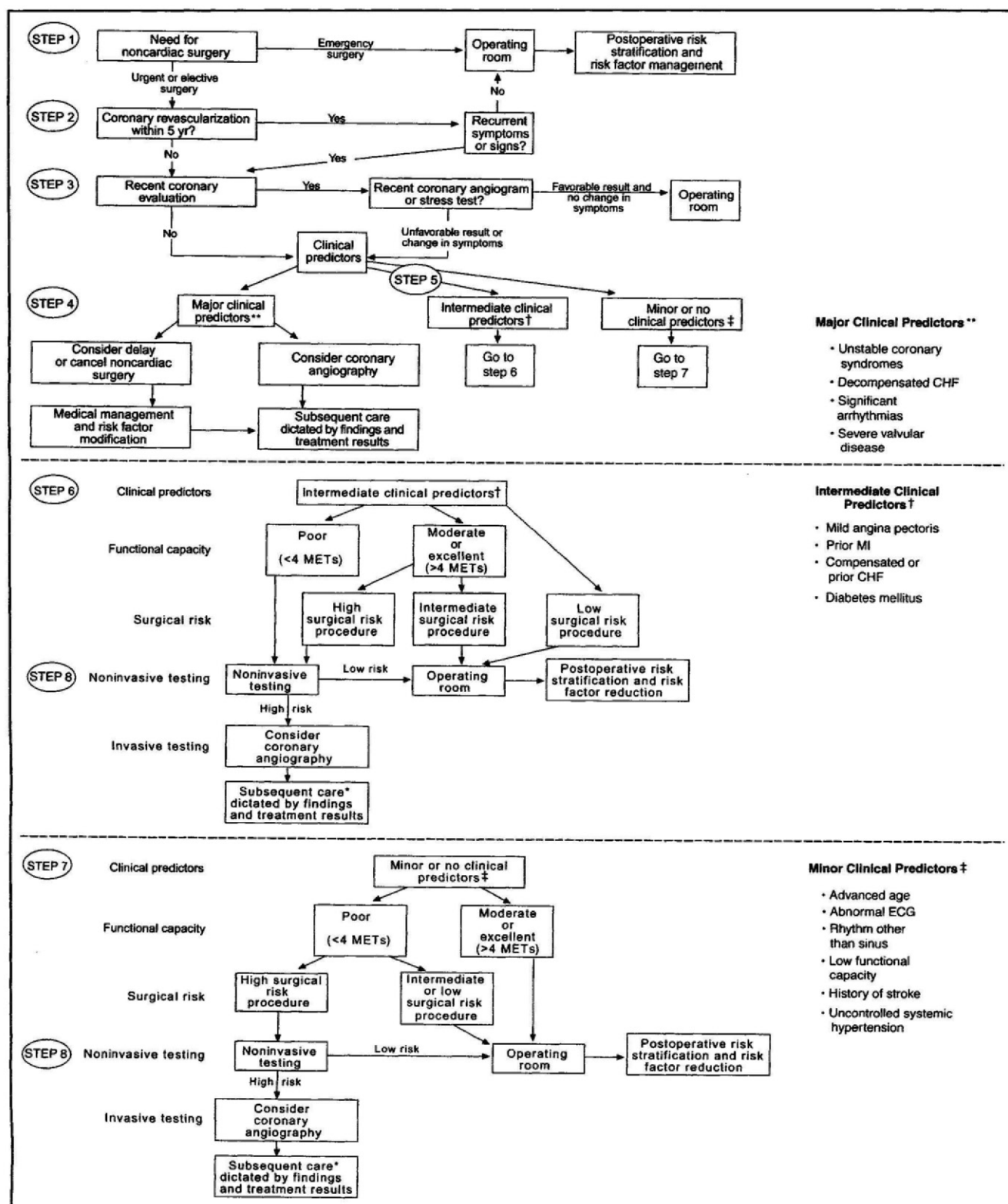


Fig. 1. Stepwise approach to preoperative cardiac assessment. Steps are discussed in detail in text. * = Subsequent care may include cancellation or delay of surgery, coronary revascularization followed by noncardiac surgery, or intensified care. CHF = congestive heart failure; ECG = electrocardiogram; METs = metabolic equivalents; MI = myocardial infarction.

Although both exercise and pharmacologic stress testing provide useful information for risk prediction, no prospective study has firmly established the cost-effectiveness or efficacy of either for improving perioperative or long-term outcomes. Use of these tests to help identify patients with advanced left main or three-vessel coronary disease is justified on the basis of overall knowledge of management of CAD; however, little or no current information justifies their use in low-risk general populations.

Ambulatory ECG Monitoring.—Several investigators have shown that detection of ischemia by using preoperative 24- to 48-hour monitoring correlates with increased risk of both early postoperative and late ischemic cardiac events. Higher-risk patients, however, may have baseline ECG abnormalities that preclude analysis, and currently the technique does not facilitate further quantification aimed at detecting those at greatest risk. Use of this technique should be limited to institutions in which preoperative monitoring of silent ischemia has been shown to be effective and in which a standardized monitoring protocol has been devised.

Coronary Angiography.—As indicated previously, proceeding directly to coronary angiography may be appropriate in certain high-risk patients (Fig. 1). Indications for coronary angiography in the preoperative setting generally are similar to those in the nonoperative setting (Table 4). First, ensure that management with percutaneous transluminal coronary angioplasty (PTCA) or coronary artery bypass grafting (CABG) is a viable option. Otherwise, coronary angiography may add to cost and risk without measurably benefiting outcome. Second, angiography should be reserved for very high-risk patients, including those with evidence of advanced ischemic risk or symptoms, particularly those suspected of having left main or three-vessel CAD.

Effects of Risk Assessment Strategies on Costs.—The degree of variation in preoperative testing before noncardiac surgery is substantial, likely a reflection of uncertainty about the most efficacious strategy or strategies and the lack of randomized clinical trials evaluating therapeutic effect on outcomes. Not surprisingly, formal cost-effectiveness analyses of various methods of preoperative testing and treatments have also yielded highly varied results. In many of these analyses, only short-term effects were evaluated; long-term benefits were ignored. Thus, the clinician should consider the cost implications of screening strategies and, when possible, rely on generally accepted strategies for treating nonsurgical patients.

Management of Specific Preoperative Cardiovascular Conditions. Hypertension.—Severe hypertension (for example, diastolic blood pressure of 110 mm Hg or greater) should be controlled before an operation when possible. The decision to delay an operation because of increased blood pressure should consider the urgency of the surgical proce-

dures and the potential benefit of intensive medical therapy. Continuation of preoperative antihypertensive treatment throughout the perioperative period is critical, particularly with agents such as β -adrenergic blockers or clonidine hydrochloride, to avoid severe postoperative hypertension.

Valvular Heart Disease.—Indications for evaluation and treatment of valvular heart disease are identical to those in the nonoperative setting. Symptomatic stenotic lesions such as mitral and aortic stenosis are associated with risk of perioperative severe CHF or shock, and often percutaneous valvotomy or valve replacement is necessary before noncardiac surgery in order to lower cardiac risk. Conversely, symptomatic regurgitant valvular disease (for example, aortic regurgitation or mitral regurgitation) is usually better tolerated perioperatively and may be stabilized preoperatively with intensive medical therapy and monitoring. Then, it is treated definitively with valve repair or replacement after noncardiac surgery. This approach is appropriate when a wait of several weeks or months before noncardiac surgery may have severe consequences—for example, in patients with surgically curable malignant neoplasms. Exceptions may include patients with both severe valvular regurgitation and reduced LV function in whom overall hemodynamic reserve is so limited that destabilization during perioperative stresses is likely.

Myocardial Heart Disease.—Dilated and hypertrophic cardiomyopathies are associated with an increased incidence of perioperative CHF. Management is directed toward maximizing preoperative hemodynamic status and providing intensive postoperative medical therapy and surveillance. An estimate of hemodynamic reserve is useful for anticipating potential complications arising from intraoperative or postoperative stress.

Arrhythmias and Conduction Abnormalities.—If an arrhythmia or cardiac conduction disturbance is present, the clinician should perform a thorough assessment for underlying cardiopulmonary disease, drug toxicity, or metabolic abnormality. Therapy should be initiated for symptomatic or hemodynamically significant arrhythmias, first to reverse any underlying condition and second to treat the arrhythmia. Indications for antiarrhythmic therapy and cardiac pacing are identical to those in the nonoperative setting.

Preoperative Coronary Revascularization. Coronary Artery Bypass Grafting.—The indications for CABG before noncardiac surgery are identical to those reviewed in the guidelines from the American College of Cardiology/American Heart Association (ACC/AHA) for CABG. Because the cardiac risk of coronary bypass itself often exceeds that of noncardiac surgery, CABG is rarely indicated to get a patient through the perioperative moment. For the patient with an unstable coronary syndrome or the apparently stable patient who has advanced left main or three-vessel disease, CABG

may, however, lead to improved long-term survival. This long-term benefit may also be noted in symptomatic patients with two-vessel disease with high-grade proximal left anterior descending coronary artery stenosis and diminished LV function. In such circumstances, when the stress of elective noncardiac surgery is likely to exceed that encountered in daily life, consideration of CABG before noncardiac surgery may be reasonable. Several observational studies have shown that patients with coronary heart disease who have successfully undergone CABG are at lower cardiac risk when they undergo noncardiac surgery.

Coronary Artery Angioplasty.—As with CABG, no controlled trials have compared perioperative cardiac outcome after noncardiac surgery for patients treated with preoperative PTCA versus medical therapy. The results of several small observational series suggest that cardiac death is infrequent in patients who have coronary angioplasty before noncardiac surgery. Several studies have demonstrated numerous complications from angioplasty, including emergency CABG in some patients. Until further data are available, the indications for PTCA in the perioperative setting are similar to those in the guidelines from the ACC/AHA for use of PTCA in general.

Medical Therapy for Coronary Artery Disease.—Few randomized trials have analyzed perioperative medical therapy to lower cardiac risk in patients having noncardiac surgery, and the data are insufficient for making firm conclusions or recommendations. Several points, however, can be made on the basis of limited observational data. First, if patients require β -blockers, calcium channel blockers, or nitrates preoperatively to control or reduce angina or its ischemic equivalent, continuation of the preoperative medical regimen into the operative and postoperative period may also protect against ischemic tendencies caused by the unique stresses of the perioperative period. The same is true for therapies used to control symptoms of CHF. Second, observational studies suggest that β -blockers reduce the frequency of postoperative ischemia, and in one study, they decreased the incidence of perioperative MI. Because postoperative ischemia is known to occur in a high percentage of patients who have subsequent development of MI, protection against ischemia may also reduce risk of MI.

Anesthetic Considerations and Intraoperative Management. **Anesthetic Agents.**—All anesthetic techniques and drugs are associated with known cardiac effects that should be considered in the perioperative plan. Apparently, no one myocardial protective anesthetic technique is best. Therefore, the choice of anesthetic and intraoperative monitors should be made by the anesthesia care team. Use of opioid-based anesthetics has become widespread because of the cardiovascular stability associated with their use, but postoperative ventilation is needed with high doses. All inhala-

tional agents have cardiovascular effects, including myocardial depression, which may be an important issue in patients with borderline LV reserve. Neuraxial techniques such as spinal and epidural anesthesia cause sympathetic blockade. Their use is frequently determined by the dermatomal level of the surgical procedure. Infrainguinal procedures may be accompanied by minimal hemodynamic changes if neuraxial blockade is limited to those dermatomes. Abdominal operations that necessitate a high dermatomal level of anesthesia may result in more profound effects, including hypotension and reflex tachycardia if preload decreases or hypotension without tachycardia if cardioaccelerators are inhibited by high-level blockade. Advocates of monitored anesthesia care, in which local anesthesia is supplemented by intravenous sedation or analgesia, have argued that this technique can eliminate the undesirable effects of general or neuraxial techniques, but no studies have confirmed this theory. Furthermore, failure to produce complete local anesthesia or analgesia can lead to increased stress response, which may produce myocardial ischemia or depression.

Perioperative Pain Management.—Use of patient-controlled intravenous or epidural analgesia has become widespread for reducing severity and duration of postoperative pain. Several studies suggest that effective pain management leads to a reduction in postoperative catecholamine surges and hypercoagulability, both of which can theoretically affect myocardial ischemia.

Intraoperative Nitroglycerin.—Data are insufficient to determine whether prophylactic intraoperative intravenous administration of nitroglycerin is helpful or harmful in high-risk patients. Because the vasodilating properties of nitroglycerin are mimicked by several anesthetic agents, a combination of agents may lead to severe hypotension and even myocardial ischemia. When nitroglycerin is used, the hemodynamic effects of other agents being used should be considered.

Transesophageal Echocardiography.—Few data are available on the value of transesophageal echocardiographic-detected transient wall motion abnormalities (presumed myocardial ischemia) to predict cardiac morbidity in noncardiac surgical patients. The largest experience to date suggests that the incremental value of this technique for risk prediction is minimal. Guidelines for the appropriate use of transesophageal echocardiography for diagnosis or to guide therapy are being developed by the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists.

Perioperative Surveillance. **Pulmonary Artery Catheters.**—Although a substantial amount of literature has evaluated the usefulness of pulmonary artery catheters in treating perioperative patients, few studies have compared outcomes in patients treated with or without such monitor-

ing. The American Society of Anesthesiologists believes that the following three variables are particularly important in assessing benefit versus risk of use of pulmonary artery catheters: disease severity, magnitude of anticipated surgical procedure, and practice setting. The extent of expected fluid shifts is a primary concern relative to surgical treatment. Current evidence indicates that patients most likely to benefit from use of pulmonary artery catheters perioperatively are those with a recent MI complicated by CHF, those with severe CAD who are undergoing procedures associated with pronounced hemodynamic stress, and those with systolic or diastolic LV dysfunction, cardiomyopathy, and valvular disease who are undergoing high-risk operations.

Intraoperative and Postoperative ST-Segment Monitoring.—Intraoperative and postoperative ST changes indicating myocardial ischemia have been found to be strong predictors of perioperative MI in patients at high clinical risk who undergo noncardiac surgery. Similarly, postoperative ischemia is a significant predictor of long-term MI and cardiac death. Conversely, ST depression may occur in low-risk patients who undergo noncardiac surgery. Often, this is not associated with regional wall motion abnormalities; thus, whether this is ischemia or a nonspecific finding is unknown. Currently, few data are available on the cost-effectiveness of ST-segment monitoring for the purpose of reducing perioperative morbidity in any patient population. Accumulating evidence suggests that correct use of computerized ST-segment analysis in appropriately selected high-risk patients may improve sensitivity for detection of myocardial ischemia, which could lead to improved perioperative and long-term risk assessment and treatment.

Surveillance for Perioperative MI.—Few studies have examined the optimal method for diagnosing perioperative MI. Clinical symptoms, postoperative ECG changes, and elevation of the MB fraction of creatine kinase have been most extensively studied. Newer myocardial-specific enzyme elevations such as troponin-I and troponin-T may also have value. No single strategy or combination of strategies can be strongly advocated because of the paucity of current comparative evidence. In patients without known CAD, surveillance should probably be restricted to those who have signs of cardiovascular dysfunction. In patients with known or suspected CAD undergoing high-risk procedures, obtaining electrocardiograms at baseline, immediately after the procedure, and for the first 2 postoperative days seems to be cost-effective. Use of cardiac enzymes is best reserved for patients with clinical, ECG, or hemodynamic evidence of cardiovascular dysfunction.

Postoperative Therapy and Long-Term Management.—

When possible, postoperative management should include assessment and management of modifiable risk factors for CAD, heart failure, hypertension, stroke, and other cardiovascular disorders. For many patients, the need for noncardiac surgery may be their first opportunity for a systematic cardiovascular evaluation. Assessment for hypercholesterolemia, smoking, hypertension, diabetes, physical inactivity, peripheral vascular disease, cardiac murmur, arrhythmias, conduction abnormalities, perioperative ischemia, and postoperative MI may lead to evaluation and treatments that reduce future cardiovascular risk. In particular, patients who experience repetitive postoperative myocardial ischemia or sustain a perioperative MI (or both) have a substantially increased risk of MI or cardiac death during long-term follow-up. These patients should especially undergo risk factor interventions and future risk stratification and therapy.

Appendix.—These guidelines are based on a Medline search of the English literature from 1975 through 1994, a review of selected journals from 1995, and the expert opinions of 12 committee members representing various disciplines of cardiovascular care, including general cardiology, noninvasive testing, vascular medicine, vascular surgery, anesthesiology, and arrhythmia management. In addition, draft guidelines were submitted for critical review and amendment to physicians representing internal medicine, family practice, nuclear cardiology, general surgery, and anesthesiology as well as executive officers of the ACC/AHA. The final document represents the eighth iteration over 18 months, including six drafts in committee and two additional drafts to incorporate key findings from external review.

A large proportion of the data used to develop these guidelines is based on observational or retrospective studies or knowledge of management of cardiovascular disorders in the nonoperative setting. Although the collective knowledge surrounding the identification of patients at high or low risk by using perioperative clinical and noninvasive evaluation is substantial, few prospective or randomized studies have been performed that confirm the value of tests or treatments on perioperative outcomes. Therefore, data are presented in a tabular format and, when possible, reflect the value of a test or intervention for similar outcomes of a perioperative MI or cardiac death. Because the studies were rarely randomized controlled trials, definitions of a perioperative event varied, investigators were rarely blinded, and many inherent selection biases existed, the task force chose not to provide an aggregate synthesis of the data in the form of a point estimate or meta-analysis. Presentation of the original data, however, provides substantial support for these recommendations.