ACC/AHA Practice Guidelines

ACC/AHA Guidelines for Coronary Artery Bypass Graft Surgery: Executive Summary and Recommendations

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1991 Guidelines for Coronary Artery Bypass Graft Surgery)

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Key Words: ACC/AHA Practice Guidelines • bypass • angioplasty • morbidity • mortality • revascularization • risk factors

I. Introduction
The American College of Cardiology/American Heart Association (ACC/AHA) Task Force on Practice Guidelines was formed to make recommendations regarding the appropriate use of diagnostic tests and therapies for patients with known or suspected cardiovascular disease. Coronary artery bypass graft (CABG) surgery is among the most common operations performed in the world and accounts for more resources expended in cardiovascular medicine than any other single procedure. Since the original Guidelines were published in 1991, there has been considerable evolution in the surgical approach to coronary disease, and at the same time there have been advances in preventive, medical, and percutaneous catheter approaches to therapy. These revised guidelines are based on a computerized search of the English literature since 1989, a manual search of final articles, and expert opinion.

As with other ACC/AHA guidelines, this document uses ACC/AHA classifications I, II, and III as summarized below:

**Class I:** Conditions for which there is evidence and/or general agreement that a given procedure or treatment is useful and effective.

**Class II:** Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness or efficacy of a 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/treatment is not useful/effective and in some cases may be harmful.

## II. Outcomes

### A. Hospital Outcomes

Seven core variables (priority of operation, age, prior heart surgery, sex, left ventricular [LV] ejection fraction [EF], percent stenosis of the left main coronary artery, and number of major coronary arteries with significant stenoses) are the most consistent predictors of mortality after coronary artery surgery. The greatest risk is correlated with the urgency of operation, advanced age, and 1 or more prior coronary bypass surgeries. Additional variables that are related to mortality include coronary angioplasty during index admission; recent myocardial infarction (MI); history of angina, ventricular arrhythmias, congestive heart failure, or mitral regurgitation; and comorbidities such as
diabetes, cerebrovascular disease, peripheral vascular disease, chronic obstructive pulmonary disease, and renal dysfunction. Table 1 shows a method by which key patient variables can be used to predict an individual patient's operative risk of death, stroke, or mediastinitis.

**Table 1.**

### B. Morbidity Associated With Bypass Surgery

#### 1. Neurological Events

Neurological impairment after bypass surgery may be attributable to hypoxia, emboli, hemorrhage, and/or metabolic abnormalities. Postoperative neurological deficits have been divided into 2 types: type 1, associated with major, focal neurological deficits, stupor, or coma; and type 2, in which deterioration in intellectual function is evident. Adverse cerebral outcomes are observed in \( \approx 6\% \) of patients after bypass surgery and are equally divided between type 1 and type 2 deficits. Predictors of cerebral complications after bypass surgery include advanced age and a history of hypertension. Particular predictors of type 1 deficits include proximal aortic atherosclerosis as defined by the surgeon at operation, history of prior neurological disease, use of the intra-aortic balloon pump, diabetes, hypertension, unstable angina, and increased age. Predictors of type 2 deficits include a history of excess alcohol consumption; dysrhythmias, including atrial fibrillation; hypertension; prior bypass surgery; peripheral vascular disease; and congestive heart failure. Estimation of a patient's risk for postoperative stroke can be calculated from Table 1.

#### 2. Mediastinitis

Deep sternal wound infection occurs in 1% to 4% of patients after bypass surgery and carries a mortality of \( \approx 25\% \). Predictors of this complication include obesity, reoperation, use of both internal mammary arteries at surgery, duration and complexity of surgery, and diabetes. An individual patient's risk of postoperative mediastinitis can be estimated from Table 1.

#### 3. Renal Dysfunction

Postoperative renal dysfunction occurs in as many as 8% of patients. Among patients who develop postoperative renal dysfunction (defined as a postoperative serum creatinine level >2.0 mg/dL or an increase in baseline creatinine level of >0.7 mg/dL), 18% require dialysis. Overall mortality among patients who develop postoperative renal dysfunction is 19% and approaches two thirds among patients requiring dialysis. Predictors of renal dysfunction include advanced age, a history of moderate or severe congestive heart failure, prior bypass surgery, type 1 diabetes, and prior renal disease. Table 2 can be used to estimate the risk for an individual patient. Patients with advanced preoperative renal dysfunction who undergo CABG surgery have an extraordinarily high rate of requiring postoperative dialysis. Among patients with a preoperative creatinine level >2.5 mg/dL, 40% to 50% require hemodialysis.
C. Long-Term Outcomes
Predictors of poor long-term survival after bypass surgery include advanced age, poor LVEF, diabetes, number of diseased vessels, and female sex. In some studies, additional predictors include angina class, hypertension, prior MI, renal dysfunction, and clinical congestive heart failure. Predictors of the recurrence of angina, late MI, or any cardiac event also include obesity and lack of use of an internal mammary artery, as well as those factors identified above. Of these events, the return of angina is the most common and is primarily related to late vein-graft atherosclerosis and occlusion.

III. Comparison of Medical Therapy Versus Surgical Revascularization

The comparison of medical therapy with coronary surgical revascularization is primarily based on randomized, clinical trials and large registries. Although clinical trials have provided valuable insights, there are limitations to their interpretation in the current era. Patient selection had primarily included individuals <=65 years of age, very few included large cohorts of women, and for the most part, the studies evaluated patients at low risk who were clinically stable. In addition, because the studies were done in the late 1970s and early 1980s, only 1 of the trials used arterial grafts, and even that trial had no arterial grafts in 86% of patients. Newer modalities of cardioprotection during cardiopulmonary bypass were not used, nor were minimally invasive or off-bypass techniques. Finally, medical therapy was not optimized in the trials. Lipid-lowering therapy had not yet become standard, aspirin was not widely used, and β-blockers were used in just half of the patients. Angiotensin-converting enzyme inhibitors were not being routinely used in patients with congestive heart failure or dilated cardiomyopathy. Accordingly, although the clinical trials have provided important insights, their interpretation must be viewed with caution, given the evolution in all types of coronary therapies.

For the most part, stratification of patients in the trials was based on the number of vessels with anatomically significant disease, whether or not the major epicardial obstruction was proximal, and the extent of LV dysfunction as determined by global EF. The end point of the trials was primarily survival.

Overview: Randomized Trials
There were 3 major, randomized trials and several smaller ones. A collaborative meta-analysis of 7 trials
with a total enrollment of 2649 patients has allowed comparison of outcomes at 5 and 10 years (Tables 3, 4, and 5 and the Figure). Among all patients, the extension survival of CABG surgical patients compared with medically treated patients was 4.3 months at 10 years of follow-up. The benefit of CABG compared with medical therapy in various clinical subsets is presented below.

**Table 3.** Total Mortality at 5 and 10 Years

**Table 4.** Subgroup Results at 5 Years

**Table 5.** Subgroup Analysis of 5-Year Mortality by Risk Stratum

**Figure 1.** Extension of survival after 10 years of follow-up in various subgroups of patients, from a meta-analysis of 7 randomized studies. LV indicates left ventricular; VA, Veterans Administration.
1. **Left Main Coronary Artery Disease**
   The trials defined significant left main coronary artery stenosis as a >50% reduction in lumen diameter. Median survival for surgically treated patients was 13.3 years versus 6.6 years in medically treated patients. Left main equivalent disease (≥70% stenosis in both the proximal left anterior descending [LAD] and proximal left circumflex arteries) appeared to behave similarly to true left main coronary artery disease. Median survival for surgical patients was 13.1 years versus 6.2 years for medically assigned patients. The benefit of surgery for left main coronary artery disease patients continued well beyond 10 years. By 15 years, it was estimated that two thirds of patients originally assigned to medical therapy and who survived would have had surgery. The 15-year cumulative survival for left main coronary artery disease patients having CABG surgery was 44% versus 31% for medical patients.

2. **Three-Vessel Disease**
   If one defines 3-vessel disease as stenosis of 50% or more in all 3 major coronary territories, the overall extension of survival was 7 months in CABG patients compared with medically treated patients. Patients with class III or IV angina, those with more proximal and severe LAD stenosis, those with worse LV function, and/or those with more positive stress tests derived more benefit from surgery.

3. **Proximal LAD Disease**
   In patients with severe, proximal LAD stenosis, the relative risk reduction due to bypass surgery compared with medical therapy was 42% at 5 years and 22% at 10 years. This was even more striking in patients with depressed LV function.

4. **LV Function**
   In patients with mildly to moderately depressed LV function, the poorer the LV function, the greater was the potential advantage of CABG surgery. Although the relative benefit was similar, the absolute benefit was greater because of the high-risk profile of these patients.

5. **Symptoms and Quality of Life**
   Improvement in symptoms and quality of life after bypass surgery parallels the outcome data regarding survival. Beyond survival, bypass surgery may be indicated to alleviate symptoms of angina above and beyond medical therapy or to reduce the incidence of nonfatal complications like MI, congestive heart failure, and hospitalization. Registry studies have shown a reduction in late MI among highest-risk patients, such as those with 3-vessel disease, and/or those with severe angina. In pooled analyses, a benefit on the incidence of MI was not evident. This result likely reflected an early increase in MI perioperatively after CABG, which was balanced by fewer MIs over the long term among CABG recipients. Antianginal medications were required less frequently after bypass surgery. At 5 years, two thirds of bypass patients were symptom-free compared with 38% of medically assigned patients. By 10 years, however, these differences were no longer significant. This result is related to the attrition of vein grafts in the bypass group as well as crossover of medically assigned patients to bypass surgery.

6. **Loss of Benefit of Surgery**
   After 10 to 12 years of follow-up, there was a tendency for the bypass surgery and medical therapy curves to converge, in regard to both survival as well as nonfatal outcomes. This convergence is due to a number of factors. First, the reduced life expectancy of patients with coronary disease (regardless of treatment) leads to a steady attrition. Second, the increased event rate in the late follow-up period of
surgically assigned patients was likely related to the progression of native coronary disease and graft
disease over time. Finally, medically assigned patients crossed over to surgery late, thus allowing the
highest-risk medically assigned patients to gain from the benefit of surgery later in the course of
follow-up. By 10 years, 37% to 50% of medically assigned patients had crossed over to surgery. Tables 3
4, and 5 provide estimates of long-term outcomes among patients randomized in
the trials. These tables and the Figure can be used to estimate the general survival expectations in
various anatomic categories.

IV. Comparison of Bypass Surgery With
Percutaneous Revascularization

The results of a number of randomized, clinical trials comparing
angioplasty and bypass surgery have been published. The trials
excluded patients in whom survival had already been shown to be
longer with bypass surgery than with medical therapy. Also, none
of the trials was sufficiently large to detect relatively modest
differences in survival between the 2 techniques. Most of the trials
did not have a long-term follow-up, ie, 5 to 10 years, and therefore
were unable to provide clear inferences regarding long-term benefit
of the 2 techniques in similar populations. Also, and perhaps most
notably, only 5% of screened patients with multivessel
disease at enrolling institutions were included in the trials. Half of the patients approached were ineligible
owing to left main coronary artery disease, insufficient symptoms, or other reasons. Even among a large
group of patients with multivessel disease suitable for enrollment, only half were actually randomized. It
appeared that physicians elected not to enroll many patients with 3-vessel disease in the trials but rather
refer them for bypass surgery, whereas patients with 2-vessel disease tended to be referred for
angioplasty rather than be enrolled in the trials.

Overall, procedural complications were low for both procedures but tended to be higher with CABG
surgery (Table 6). For patients randomized to angioplasty, CABG was needed in 6% during
the index hospitalization and in nearly 20% by 1 year. The initial cost and length of stay were lower for
angioplasty than for CABG. Patients having angioplasty returned to work sooner and were able to
exercise more at 1 month. The extent of revascularization achieved by bypass surgery was generally
higher than with angioplasty. Long-term survival was difficult to evaluate owing to the short period of
follow-up and the small sample size of the trials. However, for the Bypass Angioplasty Revascularization
Investigation (BARI) trial, bypass patients had a 5-year survival of 89.3% compared with 86.3% for
angioplasty. Secondary analysis revealed that in treated diabetic patients in the BARI trials, CABG led to
significantly superior survival compared with percutaneous transluminal coronary angioplasty (PTCA).
However, this finding was not evident in other trials. In long-term follow-up, the most striking difference
was the 4- to 10-fold-higher likelihood of reintervention after initial PTCA. Quality of life, physical
activity, employment, and cost were similar by 3 to 5 years after both procedures. The BARI trial suggested higher mortality associated with PTCA in several high-risk groups, including those with diabetes, unstable angina, and/or non–Q wave MI, and in patients with heart failure.

An analysis of registries generally shows data similar to those of the trials. However, a recent analysis of approximately 60,000 patients who were treated in New York State in the early 1990s provides a 3-year survival analysis of patients undergoing CABG and PTCA. After adjustment for various covariates, bypass surgery in the New York State registry experience was associated with longer survival in patients with severe proximal LAD stenosis and/or 3-vessel disease. Contrariwise, patients with 1-vessel disease not involving the proximal LAD had improved survival with PTCA. Table 7 summarizes survival data from the New York State registry with respect to various cohorts of patients undergoing angioplasty or bypass surgery. These data can be used to estimate 3-year survival expectations for patients with various anatomic features.

### V. Management Strategies

#### Reduction of Perioperative Mortality and Morbidity

1. Reducing the Risk of Type 1 Brain Injury After CABG

Postoperative neurological complications represent 1 of the most devastating consequences of CABG surgery. Type 1 injury, in which a significant, permanent, neurological injury is sustained, occurs in approximately 3% of patients overall and is responsible for a 21% mortality.

Atherosclerotic Ascending Aorta

An important predictor of this complication is the surgeon’s identification of a severely atherosclerotic, ascending aorta before or during the bypass operation. Perioperative atheroembolism from aortic plaque is thought to be responsible for approximately one third of strokes after CABG. Atherosclerosis of the ascending aorta is
strongly related to increased age. Thus, stroke risk is particularly increased in patients beyond 75 to 80 years of age. Preoperative, noninvasive testing to identify high-risk patients has variable accuracy. Computed tomography identifies the most severely involved aortas but underestimates mild or moderate involvement. Transesophageal echocardiography is useful for aortic arch examination, but examination of the ascending aorta may be limited by the intervening trachea. Intraoperative assessment with epiaortic imaging is superior to both methods. Intraoperative palpation underestimates the high-risk aorta. The highest-risk aortic pattern is a protruding or mobile aortic arch plaque. An aggressive approach to the management of patients with severely diseased ascending aortas identified by intraoperative echocardiographic imaging reduces the risk of postoperative stroke. For patients with aortic walls \( \leq 3 \) mm thick, standard treatment is used. For aortas >3 mm thick, the cannulation, clamp, or proximal anastomotic sites may be changed, or a no-clamp, fibrillatory arrest strategy may be used. For high-risk patients with multiple or circumferential involvement or those with extensive middle ascending aortic involvement, replacement of the ascending aorta under hypothermic circulatory arrest may be indicated. Alternatively, a combined approach with off-bypass, in situ internal mammary grafting to the LAD and percutaneous coronary intervention to treat other vessel stenoses has conceptual merit.

Atrial Fibrillation and Stroke

Chronic atrial fibrillation is a hazard for perioperative stroke. Intraoperative surgical manipulation or spontaneous resumption of sinus rhythm during the early postoperative period may lead to embolism of a left atrial clot. One approach to reduce this risk is the performance of preoperative, transesophageal echocardiography. The absence of a left atrial clot would suggest that the operation may proceed with acceptable risk. For elective patients, if a left atrial clot is identified, 3 to 4 weeks of anticoagulation therapy followed by restudy and then subsequent surgery is reasonable. Few clinical trial data are available to assist clinicians in this circumstance.

New-onset postoperative atrial fibrillation occurs in \( \approx \) 30% of post-CABG patients, particularly on the second and third postoperative days, and is associated with a 2- to 3-fold increased risk of postoperative stroke. Risk factors include advanced age, chronic obstructive pulmonary disease, proximal right coronary disease, prolonged operation, atrial ischemia, and withdrawal of β-blockers. The role of anticoagulants in patients who develop post-CABG atrial fibrillation is unclear. Aggressive anticoagulation and cardioversion may reduce the neurological complications associated with this arrhythmia. Early cardioversion within 24 hours of the onset of atrial fibrillation can probably be performed safely without anticoagulation. However, persistence of the arrhythmia beyond this time argues for the use of oral anticoagulants to reduce stroke risk in patients who remain in atrial fibrillation and/or in those for whom later cardioversion is planned.

Recent MI, LV Thrombus, and Stroke

Patients with a recent, anterior MI and residual wall-motion abnormality are at increased risk for the development of an LV mural thrombus and its potential for embolization. For patients undergoing surgical revascularization after sustaining an anterior MI, preoperative screening with echocardiography may be appropriate to identify the presence of a clot. Detection of an acute LV mural thrombus may call for long-term anticoagulation and reevaluation by echocardiography to ensure resolution or organization of the thrombus before coronary bypass surgery. Additionally, 3 to 6 months of anticoagulation therapy is
appropriate for patients with persistent, anterior wall–motion abnormalities after coronary bypass surgery.

**Recent, Antecedent Cerebrovascular Event**
A recent, preoperative cerebrovascular accident represents a situation in which delaying surgery may reduce the perioperative neurological risk. In particular, evidence of a hemorrhagic component based on computed tomographic scan identifies high risk for the extension of neurological damage with cardiopulmonary bypass. It is generally believed that a delay of 4 weeks or more after a cerebrovascular accident is prudent, if coronary anatomy and symptoms permit, before proceeding with CABG.

**Carotid Disease and Neurological Risk Reduction**
Hemodynamically significant carotid stenoses are thought to be responsible for up to 30% of early postoperative strokes. The trend for coronary surgery to be performed in an increasingly elderly population and the increasing prevalence of carotid disease in this same group of patients underscore the importance of this issue. Perioperative stroke risk is thought to be <2% when carotid stenoses are <50%, 10% when stenoses are 50% to 80%, and 11% to 19% in patients with stenoses >80%. Patients with untreated, bilateral, high-grade stenoses and/or occlusions have a 20% chance of stroke. Carotid endarterectomy for patients with high-grade stenosis is generally done preceding or coincident with coronary bypass surgery and, with proper teamwork in high-volume centers, is associated with a low risk for both short- and long-term neurological sequelae. Carotid endarterectomy performed in this fashion carries a low mortality (3.5%) and reduces early postoperative stroke risk to <4%, with a concomitant 5-year freedom from stroke of 88% to 96%.

The decision about who should undergo preoperative carotid screening is controversial. Predictors of important carotid stenosis include advanced age, female sex, known peripheral vascular disease, previous transient ischemic attack or stroke, a history of smoking, and left main coronary artery disease. Many centers screen all patients >65 years old. Patients with left main coronary disease are often screened, as are those with a previous transient ischemic attack or stroke. Preoperative central nervous system symptoms suggestive of vertebral basilar insufficiency should lead to an evaluation before elective CABG.

When surgery of both carotid and coronary disease is planned, the most common approach is to perform the operation in a staged manner, in which the patient first has carotid surgery followed by coronary bypass in 1 to 5 days. Alternatively, especially if the patient has compelling cardiac symptoms or coronary anatomy, the operations may be performed during a single period of anesthesia, with the carotid endarterectomy immediately preceding coronary bypass. Neither strategy has been established as being superior. Stroke risk is increased if a reversed-stage procedure is used, in which the coronary bypass operation precedes the carotid endarterectomy by \( \geq 1 \) day.

2. **Reducing the Risk of Type 2 Brain Injury**
Type 2 neurological complications are seen in \( \approx 3\% \) of patients and are correlated with a 10% risk of postoperative death, with 40% of patients requiring additional care in a transitional facility after hospital discharge. Microembolization is thought to be a major contributor to the postoperative cerebral dysfunction after CABG. The release of microemboli during extracorporeal circulation, involving small
gaseous or lipid emboli, may be responsible. The use of a 40-µm arterial-line filter on the heart-lung machine circuit and routine use of membrane oxygenators rather than bubble oxygenators may reduce such neurological injury. Additional maneuvers to reduce type 2 neurological injury include the maintenance of steady, cerebral blood flow during cardiopulmonary bypass, avoidance of cerebral hyperthermia during and after cardiopulmonary bypass, meticulous control of perioperative hyperglycemia, and avoidance and limitation of postoperative cerebral edema.

3. Reducing the Risk of Perioperative Myocardial Dysfunction

**Protection in Patients With Normal LV Function**

There is no universally applicable myocardial protection technique. Among patients with preserved preoperative cardiac function, no strong argument can currently be made for warm versus cold and crystalloid versus blood cardioplegia. However, certain techniques may offer a wider margin of safety for special patient subsets.

**Myocardial Protection for Acutely Depressed Cardiac Function**

Several studies have suggested that blood cardioplegia (compared with crystalloid) may offer a greater margin of safety during CABG performed on patients with acute coronary occlusion, failed angioplasty, urgent revascularization for unstable angina, and/or chronically impaired LV function.

**Protection for Chronically Depressed LV Function**

The use of a prophylactic intra-aortic balloon pump as an adjunct to myocardial protection may reduce mortality in patients having CABG in the setting of severe LV dysfunction (eg, LVEF <0.25). Placement of the intra-aortic balloon pump immediately before operation appears to be as effective as placement on the day preceding bypass surgery.

**Adjuncts to Myocardial Protection**

Although it is widely appreciated that use of the internal mammary artery leads to improved long-term survival after coronary bypass surgery, it has also been documented that use of the internal mammary artery influences operative mortality itself. Thus, internal mammary artery use should be encouraged in the elderly, emergent, or acutely ischemic patient and other patient groups.

**Inferior Infarct With Right Ventricular Involvement**

An acutely infarcted right ventricle is at great risk for severe, postoperative dysfunction and predisposes the patient to a higher postoperative mortality. During operation, loss of the pericardial constraint may lead to acute dilatation of the dysfunctional right ventricle, which then fails to recover even with optimal myocardial protection and revascularization. The best defense against right ventricular dysfunction is its recognition during preoperative evaluation. When possible, CABG should be delayed for \( \geq 4 \) weeks to allow the right ventricle to recover.

4. Reducing the Systemic Consequences of Cardiopulmonary Bypass

A variety of measures have been tried to reduce the systemic consequences of cardiopulmonary bypass, which elicits a diffuse inflammatory response that may cause transient or prolonged multisystem organ dysfunction. Administration of corticosteroids before cardiopulmonary bypass may reduce complement activation and release of proinflammatory cytokines. Proper timing and duration of corticosteroid application are incompletely resolved. The administration of the serine protease inhibitor aprotinin may attenuate complement activation and cytokine release during extracorporeal circulation. Unfortunately,
aprotinin is relatively expensive. Another method to reduce the inflammatory response is perioperative leukocyte depletion through hematologic filtration.

5. Reducing the Risk of Perioperative Infections
Several methods exist to reduce the risk of wound infections in patients undergoing CABG. These begin with interval reporting to individual surgeons regarding their respective wound infection rates and adherence to sterile operative techniques. Additional strategies include skin preparation with topical antiseptics, clipping rather than shaving the skin, avoidance of hair removal, reduction of operating room traffic, laminar-flow ventilation, shorter operation, minimization of electrocautery, avoidance of bone wax, use of double-glove barrier techniques for the operating room team, and routine use of a pleural pericardial flap. Aggressive, perioperative glucose control in diabetics through the use of continuous, intravenous insulin infusion reduces perioperative hyperglycemia and its associated infection risk. Avoidance of homologous blood transfusions after CABG may reduce the risk of both viral and bacterial infections. This is due to an immunosuppressive effect of transfusion. Leukodepletion of transfused blood also reduces this effect. This can be accomplished by regional blood blanks at the time of donation or at the bedside by use of a transfusion filter.

Preoperative antibiotic administration reduces the risk of postoperative infection 5-fold. Efficacy is dependent on adequate drug tissue levels before microbial exposure. Cephalosporins are currently the agents of choice. Table 8 identifies appropriate choices, doses, and routes of therapy. A 1-day course of intravenous antimicrobials is as effective as 48 hours or more. Therapy should be administered within 30 minutes of incision and again in the operating room if the operation exceeds 3 hours. Many centers deliver antibiotics just before incision. One fail-safe method is to have the anesthesiologist administer the cephalosporin after induction but before skin incision. If deep sternal wound infection does occur, aggressive surgical debridement and early vascularized muscle flap coverage are the most effective methods for treatment, along with long-term systemic antibiotics.

Table 8. Prophylactic Antimicrobials for Coronary Artery Bypass Graft
Surgery

6. Prevention of Postoperative Dysrhythmias
Postoperative atrial fibrillation increases the length of stay, cost, and most important, the risk of stroke. Atrial fibrillation occurs in up to 30% of patients, usually on the second or third postoperative day. Methods to avoid atrial fibrillation are several. First, withdrawal of preoperative β-blockers in the postoperative period doubles the risk of atrial fibrillation after CABG. Thus, early reinitiation of β-blockers is critical for avoidance of this complication. Virtually every study of patients receiving β-blockers prophylactically has shown benefit in lowering the frequency of atrial fibrillation. Most have used the drug in the postoperative period, but greater benefit may occur if β-blockade is begun before the operation. More recently, small studies of propafenone, sotalol, and amiodarone have also shown effectiveness in reducing the risk of postoperative atrial fibrillation. Table 9 provides a review of
pharmacological approaches in the randomized trials. Digoxin and calcium channel blockers have no consistent benefit for preventing atrial fibrillation after CABG, although they are frequently used to control its rate after it does occur. Currently, the routine preoperative or early postoperative administration of β-blockers is considered standard therapy to reduce the risk of atrial fibrillation after CABG.

7. Strategies to Reduce Perioperative Bleeding and Transfusion Risk

Transfusion Risk
Despite the increasing safety of homologous blood transfusion, concerns surrounding viral transmission during transfusion remain. Currently, the risks are likely very low and have been estimated to be 1/493 000 for human immunodeficiency virus, 1/641 000 for human T-cell lymphotrophic virus, 1/103 000 for hepatitis C virus, and 1/63 000 for hepatitis B virus.

Perioperative Bleeding
Risk factors for blood transfusion after CABG include advanced age, low preoperative red blood cell volume, preoperative aspirin therapy, urgent operation, duration of cardiopulmonary bypass, recent thrombolytic therapy, reoperation, and differences in heparin management. Institutional protocols that establish minimum thresholds for transfusion lead to a reduced number of units transfused and the percentage of patients requiring blood. Additional strategies can reduce the transfusion requirement after CABG. For stable patients, aspirin and other antiplatelet drugs may be discontinued 7 days before elective CABG. Aprotinin, a serum protease inhibitor with antifibrinolytic activity, also decreases postoperative blood loss and transfusion requirements in high-risk patients. Although there has been some concern that aprotinin may reduce early graft patency, recent studies have failed to document this effect. Routine use of aprotinin is limited by its high cost. Multidisciplinary approaches to conserve blood in single institutions appear to be effective.

For patients without exclusions, such as low hemoglobin values, heart failure, unstable angina, left main coronary artery disease, or advanced anginal symptoms, self-donation of 1 to 3 units of red blood cells over 30 days before operation reduces the need for homologous transfusion during or after operation. Donation immediately before cardiopulmonary bypass yields a higher platelet and hemoglobin count compared with simple hemodilution without pre–cardiopulmonary bypass blood harvesting.

8. Antiplatelet Therapy for Saphenous Vein Graft Patency
Aspirin significantly reduces vein graft closure during the first postoperative year. The aspirin should be started within 24 hours after surgery because its benefit on saphenous vein graft patency is lost when begun later. Dosing regimens from as little as 100 mg/d to as much as 325 mg TID appear to be efficacious. Ticlopidine offers no advantage over aspirin but is an alternative in truly aspirin-allergic patients. Life-threatening neutropenia is a rare but recognized side effect. Clopidogrel offers the potential
for fewer side effects compared with ticlopidine as an alternative in aspirin-allergic patients. Its incidence of severe leukopenia is rare.

9. Pharmacological Management of Hyperlipidemia
Aggressive treatment of hypercholesterolemia reduces progression of atherosclerotic vein graft disease in patients after bypass surgery. Statin therapy has been shown to reduce saphenous vein graft disease progression over the ensuing years after bypass. Patients with unknown low-density lipoprotein (LDL) cholesterol levels after bypass should have cholesterol levels determined and treated pharmacologically if the LDL exceeds 100 mg/dL. Patients with treated LDL cholesterol should have their low-fat diet and cholesterol-lowering medications continued after bypass surgery to reduce subsequent graft attrition. Data regarding the benefit of cholesterol lowering after bypass surgery are most supported by studies that have used HMG CoA (3-hydroxy-3-methylglutaryl coenzyme A) reductase inhibitors, particularly targeting LDL levels to <100 mg/dL.

10. Hormonal Manipulation
While observational studies have suggested that hormone replacement therapy in postmenopausal women leads to a reduction in all-cause mortality, a recent, randomized trial for secondary coronary prevention failed to show a beneficial effect on the overall rate of coronary events. Thus, hormone replacement therapy should be considered in postmenopausal women after bypass when, in the physician's judgment, the potential coronary benefit is not offset by an increased risk of uterine or breast cancer.

11. Smoking Cessation
Smoking cessation is the single, most important risk-modification goal after CABG in patients who smoke. Smoking cessation leads to less recurrent angina, improved physical function, fewer admissions, maintenance of employment, and improved survival. Depression may be an important complicating factor and should be approached with behavioral and drug therapy. Nicotine replacement with a transdermal patch, nasal spray, gum, or inhaler is beneficial. A sustained-release form of bupropion, an antidepressant similar to selective serotonin reuptake inhibitors, reduces the nicotine craving and anxiety of smokers who quit. All smokers should receive educational counseling and be offered smoking cessation therapy after CABG (Table 10).

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12. Cardiac Rehabilitation
Cardiac rehabilitation, including early ambulation during hospitalization, outpatient prescriptive exercise, family education, and dietary and sexual counseling, has been shown to improve outcomes after CABG. The benefits include better physical mobility and perceived health. A higher proportion of rehabilitated patients are working at 3 years after CABG. The benefits of rehabilitation extend to the elderly and to women. Cardiac rehabilitation reinforces pharmacological therapy and smoking cessation and should be offered to all eligible patients after CABG.
13. Emotional Dysfunction and Psychosocial Considerations
Lack of social participation and low religious strength are independent predictors of death in elderly patients undergoing CABG. Although controversial, the high prevalence of depression after bypass surgery may reflect a high prevalence preoperatively. Cardiac rehabilitation has a highly beneficial effect in patients who are moderately or severely depressed. Evaluation of social supports and attempts to identify and treat underlying depression should be part of routine post-CABG care.

14. Rapid Sustained Recovery After Operation
Rapid recovery and early discharge are standard goals after CABG. The shortest in-hospital postoperative stays are followed by the fewest rehospitalizations. Important components of "fast-track" care are careful patient selection, patient and family education, early extubation, prophylactic antiarrhythmic therapy, dietary considerations, early ambulation, early outpatient telephone follow-up, and careful coordination with other physicians and healthcare providers.

15. Communication Between Caregivers
Maintenance of appropriate and timely communication between treating physicians regarding care of the patient is crucial. When possible, the primary care physician should follow up the patient during the perioperative course. The referral physician needs to provide clear, written reports of the findings and recommendations to the primary care physician, including discharge medications and dosages along with long-term goals.

VI. Impact of Evolving Technology

A. Less-Invasive Coronary Bypass Surgery
Technical modifications of CABG have been developed to decrease the morbidity of the operation, either by using limited incision or by eliminating cardiopulmonary bypass. Currently, "less-invasive" CABG surgery can be divided into 3 categories: (1) off-bypass CABG performed through a median sternotomy with a smaller skin incision, (2) minimally invasive direct CABG (MID-CAB) performed through a left anterior thoracotomy without cardiopulmonary bypass, and (3) port-access CABG with femoral-to-femoral cardiopulmonary bypass and cardioplegic arrest with limited incision.

Off-bypass coronary surgery is performed on a beating heart after reduction of cardiac motion with a variety of pharmacological and mechanical devices. These include slowing the heart with β-blockers and calcium channel blockers and use of a mechanical stabilizing device to isolate and stabilize the target vessel. Retraction techniques may elevate the heart to allow access to vessels on the lateral and inferior surfaces of the heart. Because this technique generally uses a median sternotomy, its primary benefit is the avoidance of cardiopulmonary bypass, not a less extensive incision.

MID-CAB refers to bypass surgery without median sternotomy and without the use of cardiopulmonary...
bypass. Generally, this is performed with a small left anterior thoracotomy, exposing the heart through the fourth intercostal interspace with access to the LAD and diagonal branches and occasionally, the anterior marginal vessels. The right coronary artery can be approached by using a right anterior thoracotomy. MID-CAB procedures are generally performed on only 1 or 2 coronary targets. Observational studies have suggested that MID-CAB is associated with a reduced average length of stay and an earlier return to work. Although initial reports of 2-year actuarial and event-free survival are encouraging, the data must be viewed with caution. Because the number of anastomoses performed on a beating heart is usually 1 or occasionally 2, the potential long-term effects of incomplete revascularization are unknown.

The closed-chest, port-access, video-assisted CABG operation uses cardiopulmonary bypass and cardioplegia of a globally arrested heart. Vascular access for cardiopulmonary bypass is achieved via the femoral artery and vein. A triple-lumen catheter with an inflatable balloon at its distal end is used to achieve endovascular aortic occlusion, cardioplegia delivery, and LV decompression. With cardiopulmonary bypass and cardioplegic arrest, CABG can be performed with video assistance on a still and decompressed heart through several small ports. In comparison with the MID-CAB, port access allows access to different areas of the heart, thus facilitating more complete revascularization, and the motionless heart may allow a more accurate anastomosis. Compared with conventional CABG, median sternotomy is avoided. However, potential morbidity of the port-access operation includes multiple wounds at port sites, the limited thoracotomy, and the groin dissection for femoral-femoral bypass. Vigorous scrutiny of the long-term benefits versus risks of port access is required.

B. Arterial and Alternate Conduits

Another area of evolving technology is the use of arterial and alternate conduits. The 5-year patency of coronary artery–vein bypass grafts is 74%, and at 10 years, just 41%. Contrariwise, patency rates of the internal mammary artery implanted into the LAD are as high as 83% at 10 years. As a consequence of improved patency, patients receiving an LAD graft with an internal mammary artery have improved survival compared with patients receiving only vein grafts. Currently, routine use of the left internal mammary artery for LAD grafting with supplemental saphenous vein grafts to other coronary lesions is generally accepted as a standard grafting method. The use of bilateral internal mammary arteries appears to be safe and efficacious. However, there is a higher rate of deep sternal wound infection when both internal mammary arteries are used. This is particularly true for patients with obesity and diabetes and perhaps for those requiring prolonged ventilatory support. The benefits of bilateral internal mammary artery use include lower rates of recurrent angina, MI, and need for reoperation and a trend for better survival. Recently, the radial artery has been used more frequently as a conduit for coronary bypass surgery. Five-year patency appears to be in the range of 85% (compared with nearly 90% for the internal mammary graft). In patients for whom mammary artery, radial artery, and standard vein conduits are unavailable, the in situ right gastroepiploic artery, the inferior epigastric free artery graft, and either lesser saphenous or upper-extremity vein conduits have been used. Long-term patency of these alternative grafts has not been extensively studied.

C. Percutaneous Technology

Technological improvements in percutaneous coronary angioplasty have included the introduction of
new devices and improved medical therapy of patients in whom angioplasty is performed. The most notable improvement has been the introduction of intracoronary stents that have reduced late restenosis and the frequency with which emergency bypass surgery is required after PTCA. Intracoronary stents have been used to treat saphenous vein graft stenosis in patients with previous CABG. However, stented patients still have an approximate 25% combined rate of death, MI, need for repeat CABG, or re-revascularization of the target vessel. For some patients, hybrid procedures may be the best choice, such as the combined use of CABG surgery and coronary angioplasty. Such an approach is relevant to the patient whose ascending aorta is involved with severe atherosclerosis, for which the implantation of free vein grafts or arterial grafts leads to risk for atheroembolism. In such a patient, the use of in situ internal mammary artery grafting without cardiopulmonary bypass combined with additional coronary angioplasty in other diseased vessels represents a strategy to provide complete revascularization without the concomitant risks of cardiopulmonary bypass and/or manipulation of the ascending aorta.

D. Transmyocardial Revascularization
A fourth area that is rapidly evolving is transmyocardial revascularization. The use of transmyocardial laser revascularization has generally been performed surgically for patients with severe angina refractory to medical therapy and who are not suitable candidates for standard surgical revascularization, PTCA, or heart transplant. While several studies have suggested improvement in angina severity with transmyocardial laser revascularization, the mechanism by which angina improves and the overall benefit on long-term angina and/or survival await further clarification.

VII. Special Patient Subsets

A. Elderly Patients
Elderly patients being considered for CABG have a higher average risk for mortality and morbidity in a direct relation to age, LV function, extent of coronary disease, and comorbid conditions and whether the procedure is urgent, emergent, or a reoperation. Nonetheless, functional recovery and sustained improvement in the quality of life can be achieved in the majority of such patients. The patient and physician together must explore the potential benefits of improved quality of life with the attendant risks of surgery versus alternative therapies that take into account baseline functional capacities and patient preferences. Age alone should not be a contraindication to CABG if it is thought that long-term benefits outweigh the procedural risk.

B. Women
A number of earlier reports had suggested that female sex was an independent risk factor for mortality and morbidity after CABG. More recent studies have suggested that women on average have a disadvantageous, preoperative clinical profile that accounts for much of this perceived difference. Thus, the issue is not necessarily sex itself but the comorbid conditions that are particularly associated with the
later age at which women present for coronary surgery. Thus, CABG should not be delayed in or denied to women who have appropriate indications.

C. Diabetic Patients
Coronary heart disease is the leading cause of death among adult diabetics and accounts for 3 times as many deaths among diabetics as among nondiabetics. While CABG carries an increased morbidity and mortality in diabetics, data suggest that in appropriate candidates, the absolute risk reduction provided by successful revascularization remains high. The BARI trial suggested that diabetics with multivessel coronary disease derived advantage from bypass surgery compared with angioplasty. Several of the other randomized trials, albeit with smaller numbers of patients, failed to show this trend. Diabetics who are candidates for renal transplantation have a particularly high incidence of coronary artery disease, even in the absence of symptoms or signs. In appropriate candidates, CABG appears to offer morbidity and mortality benefit in such patients.

D. Patients With Chronic Obstructive Pulmonary Disease
Because CABG is associated with variable degrees of postoperative respiratory insufficiency, it is important to identify patients at particular risk for pulmonary complications. The intent is to treat reversible problems that may contribute to respiratory insufficiency in high-risk patients, with the hope of avoiding prolonged periods of mechanical ventilation after CABG. High-risk patients often benefit from preoperative antibiotics, bronchodilator therapy, a period of cessation from smoking, perioperative incentive spirometry, deep-breathing exercises, and chest physiotherapy. If pulmonary venous congestion or pleural effusions are identified, diuresis often improves lung performance.

Although preoperative spirometry directed to identifying patients with a low (eg, <1 L) 1-second forced expiratory volume has been used by some to qualify or disqualify candidates for CABG, clinical evaluation of lung function is likely as important if not more so. Patients with advanced chronic obstructive pulmonary disease are at particular risk for postoperative arrhythmias that may be fatal. While moderate to severe degrees of obstructive pulmonary disease represent a significant risk factor for early mortality and morbidity after CABG, it is also true that with careful preoperative assessment and treatment of the underlying pulmonary abnormality, many such patients are successfully carried through the operative procedure.

E. Patients With End-Stage Renal Disease
Coronary artery disease is the most important cause of mortality in patients with end-stage renal disease. Many of such patients have diabetes and other coronary risk factors, including hypertension, myocardial dysfunction, abnormal lipids, anemia, and increased plasma homocysteine levels. Although patients on chronic dialysis are at higher risk when undergoing coronary angioplasty or bypass, they are at even higher risk with conservative medical management. Thus, in patients with modest reductions in LV function, significant left main or 3-vessel disease, and/or unstable angina, coronary revascularization can lead to relief of coronary symptoms, improvement in overall functional status, and improved long-term survival in this select high-risk patient population.

F. Reoperative Patients
Operative survival and long-term benefit of reoperative CABG are distinctly inferior to first-time
operations. Patients undergoing repeated CABG have higher rates of postoperative bleeding, perioperative MI, and neurological and pulmonary complications. Nevertheless, reasonable 5- and 10-year survival rates after reoperation for coronary disease can be achieved, and the operation is appropriate if the severity of symptoms and anticipated benefit justify the immediate risk. Data suggest that the need for reoperation is less common in patients undergoing internal mammary artery grafting to the LAD. More recently, short-term follow-up studies suggest that patients undergoing multiple arterial grafts have even lower rates of reoperation. These early results are consistent with the known superior graft patency of arterial conduits compared with vein grafts.

G. Concomitant Peripheral Vascular Disease
The presence of clinical and subclinical peripheral vascular disease is a strong predictor of increased hospital and long-term mortality rates in patients undergoing CABG. However, the absolute benefit offered by coronary revascularization is elevated in patients with peripheral vascular disease, particularly those with 3-vessel coronary disease, more advanced angina, and/or a depressed LVEF. Excess perioperative mortality in such patients is related to an increased incidence of heart failure and dysrhythmias rather than peripheral arterial complications.

H. Poor LV Function
Patients with severe LV dysfunction have increased perioperative and long-term mortality compared with patients with normal LV function. However, studies suggest that the beneficial effects of myocardial revascularization in patients with ischemic heart disease and severe LV dysfunction are sizeable when compared with medically treated patients of similar status in terms of symptom relief, exercise tolerance, and survival.

I. CABG in Acute Coronary Syndromes
Coronary bypass surgery offers a survival advantage compared with medical therapy in patients with unstable angina and LV dysfunction, particularly in the presence of 3-vessel disease. However, the risk of bypass surgery in patients with unstable or postinfarction angina or early after non–Q wave infarction and during acute MI is increased severalfold compared with patients with stable angina. Although this risk is not necessarily higher than that with medical therapy, it has led to the argument to consider angioplasty or to delay CABG in such patients if medical stabilization can be easily accomplished.

VIII. Institutional and Operator Competence
Studies suggest that mortality after CABG is higher when carried out in institutions that annually perform fewer than a minimum number of cases. Similar conclusions have been drawn regarding individual surgeons’ volumes. This observation strengthens the argument for careful outcome tracking and supports the monitoring of institutions or individuals who annually perform <100 cases. It is also true that there is a wide variation in risk-adjusted mortality rates in low-volume situations. Thus, some institutions and practitioners maintain excellent outcomes despite relatively low volumes.

Outcome reporting in the form of risk-adjusted mortality rates after bypass has been effective in reducing
mortality rates nationwide. Public release of hospital and physician-specific mortality rates has not been shown to drive this improvement and has failed to effectively guide consumers or alter physician referral patterns.

IX. Cost-Effectiveness of Bypass Surgery

A variety of studies of CABG have found the technique to be cost-effective in patients for whom survival and/or symptomatic benefit is demonstrable. Within these subsets, the cost-effectiveness of CABG compares favorably with that of other accepted medical therapies.

When compared with PTCA, the initial hospital cost of CABG is significantly higher. However, by 5 years, the cumulative cost of PTCA compared with initial surgical therapy is within 5% of CABG, or a difference of <$3000. Observational studies showing a poorer survival effect of PTCA in patients with more advanced disease suggest that there may be a significant cost gradient for PTCA as the extent of disease increases, which is not apparent for coronary bypass surgery.

A. Indications for CABG in Asymptomatic or Mild Angina

Class I
1. Significant left main coronary artery stenosis.

2. Left main equivalent: significant (\( \geq 70\% \)) stenosis of proximal LAD and proximal left circumflex artery.

3. Three-vessel disease. (Survival benefit is greater in patients with abnormal LV function; eg, with an EF <0.50.)

Class IIa
1. Proximal LAD stenosis with 1- or 2-vessel disease.*

Class IIb
1. One- or 2-vessel disease not involving the proximal LAD.\(^\text{(dagger)}\)

Class III
See text.

B. Indications for CABG in Stable Angina

Class I
1. Significant left main coronary artery stenosis.

2. Left main equivalent: significant \(\geq 70\%\) stenosis of proximal LAD and proximal left circumflex artery.

3. Three-vessel disease. (Survival benefit is greater when LVEF is <0.50.)

4. Two-vessel disease with significant proximal LAD stenosis and either EF <0.50 or demonstrable ischemia on noninvasive testing.

5. One- or 2-vessel coronary artery disease without significant proximal LAD stenosis, but with a large area of viable myocardium and high-risk criteria on noninvasive testing.

6. Disabling angina despite maximal medical therapy, when surgery can be performed with acceptable risk. If angina is not typical, objective evidence of ischemia should be obtained.

Class IIa
1. Proximal LAD stenosis with 1-vessel disease.*\(^1\)

2. One- or 2-vessel coronary artery disease without significant proximal LAD stenosis, but with a moderate area of viable myocardium and demonstrable ischemia on noninvasive testing.

Class III
1. One- or 2-vessel disease not involving significant proximal LAD stenosis, in patients (1) who have mild symptoms that are unlikely due to myocardial ischemia or have not received an adequate trial of medical therapy and (A) have only a small area of viable myocardium or (B) have no demonstrable ischemia on noninvasive testing.

2. Borderline coronary stenoses (50% to 60% diameter in locations other than the left main coronary artery) and no demonstrable ischemia on noninvasive testing.

3. Insignificant (<50% diameter) coronary stenosis.

C. Indications for CABG in Unstable Angina/Non–Q Wave MI

Class I
1. Significant left main coronary artery stenosis.

2. Left main equivalent: significant \(\geq 70\%\) stenosis of proximal LAD and proximal left circumflex artery.

3. Ongoing ischemia not responsive to maximal nonsurgical therapy.

Class IIa
1. Proximal LAD stenosis with 1- or 2-vessel disease.*1

Class IIb

2. One- or 2-vessel disease not involving the proximal LAD. {dagger}2

Class III
See text.

D. Indications for CABG in ST-Segment Elevation (Q-Wave) MI

Class I
None.

Class IIa
1. Ongoing ischemia/infarction not responsive to maximal nonsurgical therapy.

Class IIb
1. Progressive LV pump failure with coronary stenosis compromising viable myocardium outside the initial infarct area.

2. Primary reperfusion in the early hours (≤6 to 12 hours) of an evolving ST-segment elevation MI.

Class III
1. Primary reperfusion late (≥12 hours) in evolving ST-segment elevation MI without ongoing ischemia.

E. Indications for CABG in Poor LV Function

Class I
1. Significant left main coronary artery stenosis.

2. Left main equivalent: significant (≥70%) stenosis of proximal LAD and proximal left circumflex artery.

3. Proximal LAD stenosis with 2- or 3-vessel disease.

Class IIa
1. Poor LV function with significant viable, noncontracting, revascularizable myocardium without any of the aforementioned anatomic patterns.

Class III
1. Poor LV function without evidence of intermittent ischemia and without evidence of significant revascularizable, viable myocardium.

F. Indications for CABG in Life-Threatening Ventricular Arrhythmias

Class I
1. Left main coronary artery stenosis.

2. Three-vessel coronary disease.

Class IIa
1. Bypassable 1- or 2-vessel disease causing life-threatening ventricular arrhythmias.

2. Proximal LAD disease with 1- or 2-vessel disease.

Class III
1. Ventricular tachycardia with scar and no evidence of ischemia.

G. Indications for CABG After Failed PTCA
Class I
1. Ongoing ischemia or threatened occlusion with significant myocardium at risk.

2. Hemodynamic compromise.

Class IIa
1. Foreign body in crucial anatomic position.

2. Hemodynamic compromise in patients with impairment of coagulation system and without previous sternotomy.

Class IIb
1. Hemodynamic compromise in patients with impairment of coagulation system and with previous sternotomy.

Class III
1. Absence of ischemia.

2. Inability to revascularize owing to target anatomy or no-reflow state.

H. Indications for CABG in Patients With Previous CABG
Class I
1. Disabling angina despite maximal noninvasive therapy. (If angina is not typical, then objective evidence of ischemia should be obtained.)

Class IIa
1. Bypassable distal vessel(s) with a large area of threatened myocardium on noninvasive studies.

Class IIb
1. Ischemia in the non-LAD distribution with a patent internal mammary graft to the LAD supplying functioning myocardium and without an aggressive attempt at medical management and/or percutaneous revascularization.

Class III
See text.

Footnotes

"ACC/AHA Guidelines for Coronary Artery Bypass Graft Surgery: Executive Summary and Recommendations: A Report of the American College of Cardiology/American Heart Association Task
Force on Practice Guidelines (Committee to Revise the 1991 Guidelines for Coronary Artery Bypass Graft Surgery)" was approved by the American College of Cardiology Board of Trustees in March 1999 and by the American Heart Association Science Advisory and Coordinating Committee in July 1999.


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 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. 71-0173. To obtain a reprint of the complete guidelines published in the October 1999 issue of the Journal of the American College of Cardiology, ask for reprint No. 71-0174. 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 . To make photocopies for personal or educational use, call the Copyright Clearance Center, 978-750-8400.

1 Becomes Class I if extensive ischemia documented by noninvasive study and/or an LVEF <0.50.

2 If a large area of viable myocardium and high-risk criteria on noninvasive testing, becomes Class I.

3 Becomes Class I if arrhythmia is resuscitated sudden cardiac death or sustained ventricular tachycardia.

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