David C. Warltier, M.D., Ph.D., Editor

Anesthesiology 2003; 98:754–62

Preoperative Cardiology Consultation

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In a 1998 survey of New York metropolitan area anesthesiologists, surgeons, and cardiologists,[1] the three specialties were in general agreement that important purposes of a cardiology consultation are to treat an inadequately treated cardiac condition before surgery (*e.g.*, unstable angina or congestive heart failure [CHF]), to provide data to use in anesthesia management (*e.g.*, ischemic threshold of tachycardia on stress test or left ventricular ejection fraction), and possibly to diagnose a medical condition before surgery (*e.g.*, the cause of a new-onset atrial fibrillation). The yield of a cardiology consultation, in terms of new therapy or significant effect on patient management strategy prior to surgery, has, however, been reported to vary widely from 10% to more than 70%.[1–3] The reasons why the consultation process often falls short of ideal are probably multifold, but may often originate from vague understanding of the consultation process. The physician initiating the consultation, whether an anesthesiologist or a surgeon, may not make it clear to the cardiologist why the consultation is being sought. In a retrospective review of 202 cardiology consultations at a university hospital,[2] it was found that 108 just asked for an "evaluation," 79 asked for a "clearance," and 9 did not specifically request anything. Only six posed a specific question. As a result, the consultant often makes broadly inclusive, general remarks about perioperative management of the patient and may recommend preoperative diagnostic work-up that does not influence the patient's outcome but prolongs the hospital stay.[4] In this review are presented (1) the indications for cardiology consultations as implied in the American College of Cardiology–American Heart Association (ACC–AHA) guidelines on preoperative cardiac evaluation,[5] and (2) suggestions on how the ACC–AHA guidelines may be critically applied to, and improve, the consultation process.

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Received from the Beth Israel Deaconess Medical Center, and Harvard Medical School, Boston, Massachusetts. Submitted for publication January 22, 2002. Accepted for publication November 7, 2002. Support was provided solely from institutional and/or departmental sources.

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Preoperative Cardiac Consultation Based on the ACC–AHA Guidelines

The ACC–AHA guidelines on preoperative cardiac evaluation were published initially in 1996 and were also endorsed by the Society of Cardiovascular Anesthesiologists and the Society for Vascular Surgery.[6] An updated version of the guidelines was published in 2002.[5] The guidelines were based on the then-available literature as well as expert opinions from the disciplines of anesthesiology, cardiology, electrophysiology, vascular medicine, vascular surgery, and noninvasive cardiac testing. The guidelines provided an 8-step algorithm for stratifying the patient's risks and triaging to either surgery or cardiac evaluation.

The first three steps of the guidelines consider the urgency of the operation and the recency of cardiac evaluation and intervention. If the operation is not emergent and if there has not been recent cardiac evaluation and/or intervention with no significant interim changes, then the remainder of the guidelines are applied. Steps 4 through 7 deal with an assessment of the patient's clinical predictors of cardiac risk, functional status, and the risk of the surgery proposed. Step 8, or noninvasive cardiac testing to further define the patient's risk, is indicated (1) if the patient has a major clinical predictor, (2) if the patient has an intermediate clinical predictor and either has poor functional status or is undergoing a high-risk surgery, or (3) if the patient has poor functional status and is undergoing a high-risk surgery. As defined by the ACC–AHA, major clinical predictors are unstable coronary syndrome, decompensated congestive heart failure (CHF), significant arrhythmias, and severe valvular disease. Intermediate clinical predictors are mild angina pectoris, history of myocardial infarction (MI) or CHF, diabetes mellitus, and chronic renal failure with serum creatinine greater than 2 mg/dl. A high-risk surgery carries a greater than 5% perioperative risk of cardiac events such as MI, CHF, or death and is exemplified by emergent major operations, especially in the elderly, aortic, and other major vascular procedures, peripheral vascular bypass procedures, and anticipated prolonged surgical procedures associated with large fluid shifts and/or blood loss. An intermediate-risk surgery carries 1–5% perioperative risk of cardiac events and is exemplified by carotid endarterectomy, intraperitoneal and

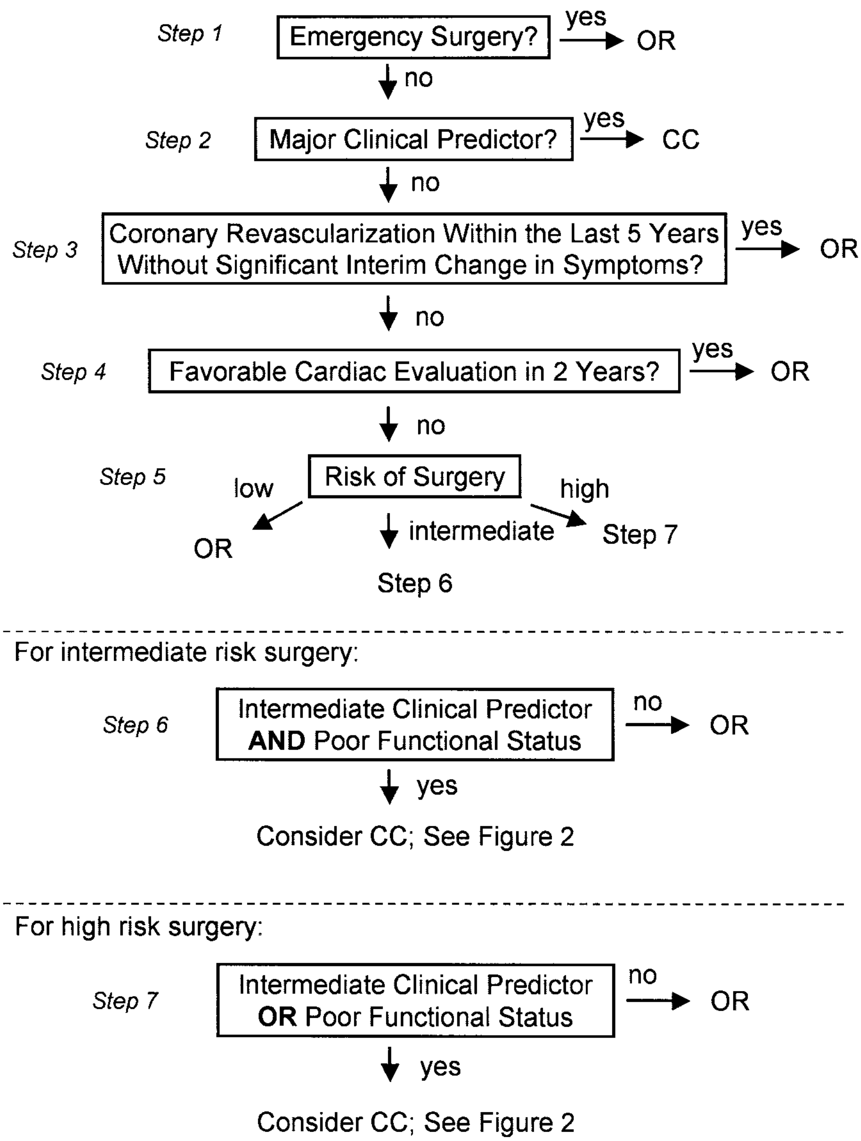


Fig. 1. Modification of the ACC–AHA guidelines to highlight indications for cardiology consultation. OR = operating room; CC = cardiology consultation. The clinical predictors, high-risk and intermediate-risk surgery, and poor functional status are defined in the text. CC may be indicated (1) for patients with a major clinical predictor, (2) for patients undergoing an intermediate risk surgery who have poor functional status and an intermediate clinical predictor, and (3) for patients undergoing a high-risk surgery who have poor functional status or an intermediate clinical predictor.

intrathoracic surgery, orthopedic surgery, head and neck surgery, and prostate surgery. Poor functional status is defined as inability to perform activities of greater than 4 metabolic equivalents (METs), where one MET is the resting metabolic rate or the amount of oxygen consumed while sitting at rest and is 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$. Activities that require less than 4 METS are exemplified by driving, cooking, bowling, walking for exercise at 5 km/h or less, raking leaves, and golfing while riding a cart.[7]

For the purpose of deciding whether to seek a cardiology consultation, the guidelines may be modified as shown in figure 1. The noncardiologist physician, whether an anesthesiologist or a surgeon, should assess (1) the presence or absence of major or intermediate clinical predictors, (2) the patient's functional status, and (3) the risk of surgery, as well as obtain information about previous cardiac intervention and testing. A satisfactory history and physical examination would usually provide all of these pieces of information. Then an anesthesiologist or a surgeon may apply the algorithm of figure 1 to determine whether consultation is indicated. If a cardiologist is vaguely asked to provide an "evaluation," the consultant is actually being asked to determine whether cardiology consultation is indicated, and if so, to take the necessary diagnostic and therapeutic measures.

A pervading theme of the updated ACC–AHA guidelines is that "in general, indications for further cardiac testing and treatments [in the operative setting] are the same as those in the nonoperative setting."[6] A patient who did not need an echocardiogram previously does not suddenly need one, because that patient is now facing surgery. In figure 1, there are three primary indications for cardiology consultations. (1) A patient with a major clinical predictor, *i.e.*, a condition that requires acute cardiac intervention such as unstable coronary syndrome should have preoperative cardiology consultation unless in need of an emergent, life-saving operation. Next, if there has not been corrective cardiac intervention or surgery within 5 yr without significant interim change in symptoms or a favorable cardiac evaluation within 2 yr, a cardiology consultation may be sought to perform any indicated noninvasive testing for stratification of risks; (2) for patients undergoing an intermediate-risk surgery who have both a poor functional capacity *and* an intermediate clinical predictor; or (3) for patients undergoing a high-risk surgery who have either an intermediate clinical predictor of cardiac risk *or* a poor functional capacity.

It should also be noted that while the ACC–AHA guidelines give examples of surgeries that may be classified as high-risk or intermediate-risk, the definition is according to the actual perioperative risk. Application of the algorithm to different groups of surgeries should be tailored to each institution's risks, whenever possible. For example, the rate of stroke or death is related to the annual surgical volume for carotid surgeries. In a survey of hospitals in Georgia,[8] a less than 3% rate of stroke or death after carotid endarterectomy was achieved only in hospitals that performed more than 50 carotid endarterectomies per year. In hospitals where carotid endarterectomy is rarely performed and carries a greater than 5% rate of perioperative cardiac events, it should be considered a high-risk surgery and the algorithm applied accordingly. While institution- and procedure-specific complication rates should ideally be used in application of the algorithm, monitoring such data may rarely be possible to most physicians.[9] Use of the ACC–AHA classification of surgical risk would provide an acceptable approach to obtaining cardiac consultations in the absence of such data.

Additional Considerations to Modify the ACC–AHA Guidelines

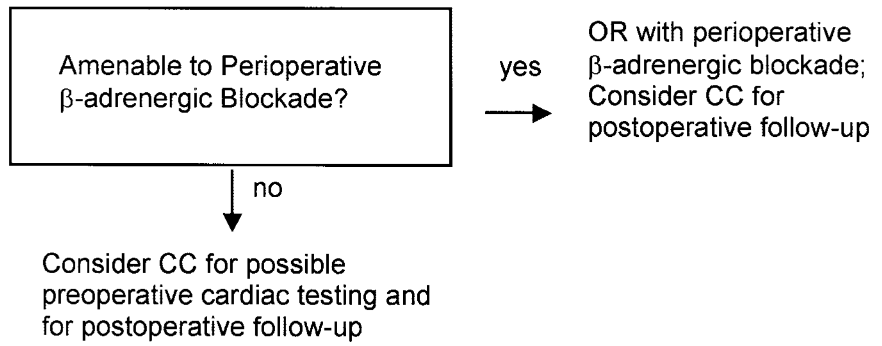
(1) Preoperative Considerations of Medical *versus* Interventional Therapy for Coronary Artery Disease (CAD). Indications for percutaneous coronary intervention or surgery for CAD are ever evolving with new studies of the relative merits of medical and surgical therapies,[10] and there is often disagreement even among the experts on what constitutes the optimal therapy.[11] Several randomized trials in the 1970s and 1980s demonstrated that surgical therapy may be preferable to medical therapy in patients with stenosis of the left main coronary artery or in patients with three-vessel disease and left ventricular dysfunction, but there appears to be no clear benefit of surgery for other patients with CAD.[12] Studies comparing percutaneous transluminal coronary angioplasty (PTCA) and medical therapy have shown that angioplasty improves exercise performance and reduces coronary symptoms to a greater extent than standard medical therapy, but may be associated with a slightly increased rate of major cardiac events such as myocardial infarction (MI) and death.[13–15] In the second Randomized Intervention Treatment of Angina (RITA-2) trial, the incidence of death or MI was 6.3% in patients treated with PTCA and 3.3% for patients treated with conservative medical care over a median follow-up period of 2.7 yr ($P = 0.02$).[15] Medical therapy, including an aggressive cholesterol-lowering regimen, may be associated with a significantly lower rate of cardiac events compared with PTCA.[16] Studies that compared coronary artery bypass graft surgery (CABG) with medical therapy were performed before the introduction of an aggressive cholesterol-lowering therapy and a new comparison such as with the ongoing COURAGE (Clinical Outcomes Utilizing Revascularization and Aggressive druG Evaluation) trial may shed a different light on the relative benefits.[17] Depending on the results of studies such as the COURAGE trial, a significant percentage of patients one refers to the cardiology consultant for the major clinical predictor of unstable coronary syndrome may be treated medically, rather than interventionally.

Anticoagulants such as low-molecular weight heparin and antiplatelet medications such as glycoprotein IIb/IIIa inhibitors play prominent roles in current medical therapy for unstable angina.[18] Therefore, patients whom the cardiology consultant opts to treat medically may not be any less enigmatic than patients who receive interventional therapy before a noncardiac surgery. Just as patients presenting for noncardiac surgery shortly after PTCA have an increased risk of restenosis or bleeding (see section 3),[19] patients on medical therapy may have the same problem of increased bleeding with continuance of the anticoagulant or of major cardiac event with discontinuance of anticoagulant regimen in the perioperative period. Whether noncardiac surgery should proceed will depend on the relative urgency of the coronary syndrome and the noncardiac surgical indication, with the understanding of the increased risk involved.

For patients with stable angina, development of oral glycoprotein IIb/IIIa inhibitors and inclusion of these medications in the treatment of stable angina will necessitate development of guidelines on perioperative management of these medications.

(2) Perioperative Use of a β-Adrenergic Blocker or an α_2 Agonist. The cardiac risk of a patient with known or suspected CAD undergoing major noncardiac surgery can be reduced with perioperative use of a β-adrenergic blocker. Recent studies with perioperative use of β-adrenergic blockade suggest that patients with suspected or known CAD may undergo major noncardiac surgery with relative safety when they are given β-adrenergic blockade perioperatively.[20–22] In particular, Poldermans *et al.*[22] studied 112 high-risk patients undergoing elective abdominal aortic or infrainguinal vascular reconstruction who had new reversible wall motion abnormalities during preoperative dobutamine stress echocardiography. The patients received bisoprolol or placebo perioperatively. Bisoprolol reduced 30-day mortality from 17 to 3.4% and nonfatal MI from 17 to 0%.

Fig. 2. For patients with indications 2 or 3 of fig. 1, determine if the patient is amenable to perioperative use of a β-adrenergic blocker. If so, institute perioperative β-adrenergic blockade. If not, one can consider cardiology consultation (CC). When a β-adrenergic blocker is started perioperatively, one should assure an appropriate follow-up with the patient's primary physician, internist, or cardiologist, so that the medication may be continued on a long-term basis, if indicated.



It should be noted that the 3.4% mortality of the bisoprolol group compares favorably to the sum of the mortality of routine CABG (3%*) and of noncardiac surgery in survivors of CABG (1.7%[23]). The benefit of perioperative bisoprolol was durable to at least 2 yr after surgery.[24] Thus for those patients who are able to take a β-adrenergic blocker, "prophylactic" coronary revascularization may not convey a survival advantage in the immediate perioperative period, even when preoperative testing indicates the presence of uncorrected CAD. For these patients, preoperative noninvasive or invasive cardiac testing itself, and therefore, preoperative cardiology consultation to perform such testing, may not be indicated. Indications 2 and 3 of figure 1 might be altered to read that if amenable, β-adrenergic blockade should be used perioperatively and cardiac consultation is not indicated for preoperative work-up. Any indicated cardiac workup and follow-up may be done postoperatively in a routine manner.

The beneficial effect of perioperative β-adrenergic blockade has been demonstrated not only with bisoprolol,[22,24] but also with atenolol,[20,21] esmolol,[25] labetalol,[26] oxprenolol,[26] and metoprolol[27] and may thus be a class effect, rather than being particular to a specific β-adrenergic blocking agent. More important than which agent is used may be how it is used. Raby *et al.*[25] advocated using a β-adrenergic blocking agent to keep the heart rate 20% below each patient's ischemic threshold or the lowest heart rate at which the patient has been demonstrated to experience myocardial ischemia. Such a regimen was shown to be beneficial in a small cohort (N = 26) of patients undergoing vascular surgery. Tailoring the dose of the β-adrenergic blocker to each patient may be logical, but no rationale for choosing a target rate 20% below the ischemic threshold was presented. In many patients, the ischemic threshold is not known. A reasonable rule of thumb may be that the anesthesiologist should use a β-adrenergic blocker perioperatively to achieve a heart rate that is as low as possible without causing inadequate levels of coronary perfusion pressure, and that if the ischemic threshold is known, is below it.

Despite the literature evidence on the benefit of perioperative β-adrenergic blockade, it has been greatly underutilized in surgical patients.[28,29] Commonly accepted relative contraindications to the use of a β-adrenergic blocker include CHF or poor ventricular function, bronchospastic disease, symptomatic bradycardia or heart block, and allergies to β-adrenergic blockers.[28] Studies of perioperative use of β-adrenergic blockers[20,21] report how well the drugs are tolerated without detectable side effects. Furthermore, the perioperative period represents a special situation in which tolerance to the drugs can be rapidly assessed, and if necessary, a deleterious effect is promptly reversed.[28]

Whether perioperative use of an α_2 adrenergic agonist may confer a similar benefit to perioperative β-adrenergic blockade has been studied.[30–32] A meta-analysis of the literature on the efficacy of clonidine demonstrated that while myocardial ischemia might be reduced, the incidence of myocardial infarction or death did not decrease with the medication.[32] Literature evidence for the benefit of perioperative use of an α_2 agonist is not as strong as that for the benefit of β-adrenergic blockade and the amenability of using an α_2 agonist perioperatively should not be considered to obviate the need for cardiology consultation when indicated (Indications 2 and 3 of fig. 1).

If a β-adrenergic blocker or other drug is started in the perioperative period, then the surgical team (the surgeon and the anesthesiologist) should assure a proper postoperative follow-up with either a cardiologist, an internist, or a family physician, so that if indicated, the patient may be continued on the medication on a long-term basis (fig. 2). Data on the benefit of continuing a β-adrenergic blocker or an α_2 agonist started perioperatively is currently lacking.

In the ACC–AHA decision tree, no explicit consideration is given to the presence of a single intermediate clinical predictor of cardiac risk *versus* the presence of multiple intermediate clinical predictors. But the literature indicates that the perioperative risk of cardiac events increases with the number of risk factors.[33,34] In

*The Society of Thoracic Surgeons national database. Available at: http://www.sts.org/section/stsdatabase. Accessed December 12, 2001.

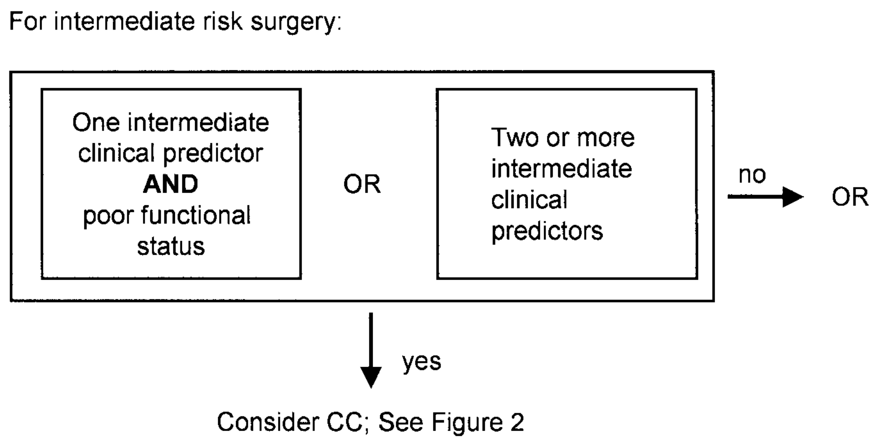


Fig. 3. Modification of Step 6 of fig. 1 (indication 2 for cardiology consultation [CC]) to account for the increased cardiac risk in the presence of multiple intermediate clinical predictors. For patients undergoing an intermediate risk surgery, consider the algorithm of fig. 2, if they have multiple intermediate clinical predictors or a single intermediate clinical predictor and poor functional status.

a study of 4,315 patients undergoing elective major noncardiac surgeries, Lee *et al.*[33] found six independent predictors of complications: high-risk surgery, history of CAD, history of CHF, history of cerebrovascular disease, preoperative treatment with insulin, and preoperative creatinine greater than 2.0 mg/dl —mostly the same as the intermediate clinical predictors of the ACC–AHA guidelines. The presence of 0, 1, 2, or more than 3 of these risk factors was associated with 0.4, 0.9, 7, and 11% risks, respectively, of cardiac events. There was also a higher complication rate in patients with poor functional capacity (2.98 *vs.* 1.03% in those with good functional capacity, $P < 0.05$). It may be noted that even in the study by Lee *et al.*, high-risk surgery itself is an independent predictor of risk and poor functional capacity is associated with a poor outcome. The importance of multiple intermediate clinical predictors can be taken into account, by changing Step 6 of the algorithm in figure 1 from "Intermediate clinical predictor and poor functional capacity?" to "An intermediate clinical predictor and poor functional capacity" or "Two intermediate clinical predictors?" (fig. 3).

(3) Coronary Revascularization before Noncardiac Surgery?. In the ACC–AHA guidelines, coronary revascularization may be considered if the result of the invasive and/or noninvasive cardiac testing is positive for significant CAD. Revascularization either by percutaneous transluminal coronary angioplasty (PTCA) with or without stenting or by coronary artery bypass graft surgery (CABG) may confer long-term symptom-free survival benefit in certain patients with CAD (see section 1).[12–15] However, to triage the patient to undergo coronary revascularization *before* noncardiac surgery to reduce the perioperative cardiac risk of the latter surgery, three conditions should be satisfied. These conditions are (1) that the combined risk of coronary angiography and coronary revascularization does not exceed the risk of the proposed noncardiac surgery performed without revascularization, (2) that coronary revascularization should significantly lower the cardiac risk of the subsequently performed noncardiac surgery, with the magnitude of risk reduction preferably greater than the risk of coronary angiography and revascularization, and (3) that the recovery time from coronary revascularization should be short enough so that the proposed noncardiac surgery, especially if it is urgent, is not unduly delayed. When these conditions are not met, any indicated revascularization may be performed *after* the noncardiac surgery.

First then, one needs to know the risk of coronary angiography and revascularization, especially relative to the risk of the proposed noncardiac surgery performed without revascularization. Although the risk of coronary angiography and revascularization is expected to vary from one institution to the next, the national mortality rate from CABG in the U.S. was approximately 3% in 1998*. The mortality was higher if the surgery was accompanied by a valve replacement (7% for CABG and aortic valve replacement and 12% for CABG and mitral valve replacement), if the surgery was emergent (6% for pristine emergent CABG and 13.5% for redo emergent CABG), for redo surgeries (5.4% for elective redo surgeries), for females (3.9 *vs.* 2.3% for males), and for the elderly (4.1% for those in their 70s and 6.7% for those in their 80s). It should be also noted that for patients with a major clinical predictor of cardiac risk such as unstable angina or evolving MI, the cardiac surgical intervention is likely to be performed emergently or urgently, thus raising the mortality and morbidity of CABG. For PTCA performed electively, the mortality from the procedure in 1996–1998 was 0.5% and another 0.5% had to be taken to urgent CABG, where the mortality may be as high as 8.8% if the time from PTCA to CABG is less than 6 h.[35] For PTCA, however, one needs to consider not only the mortality associated with the procedure, but also its immediate success rate, since the procedure often results in inadequate recanalization of the stenotic or occluded coronary artery. The mortality and the immediate success rate of PTCA depend on the severity of the coronary lesion and the urgency with which the procedure is performed.[36] For PTCA of coronary arteries with class IV lesions in the setting of an acute MI, the in-hospital mortality is over 3%, emergency CABG rate is over 3%, the rate of nonfatal major complications is nearly 8%, and the immediate success rate of PTCA is only 75%. A large number of these patients may be exposed to a significant risk with no immediate realized benefit when referred to PTCA. Conversely, elective PTCA of coronary arteries with class I lesions may carry a mortality of less than 0.5%, a nonfatal complication rate of 2%, and an immediate success rate of nearly 97%. Preferably one should be aware of the mortality and success rates for either CABG or PTCA under each specific situation at one's own institution or referral center when considering revascularization *versus* medical optimization and compare them to the risk of proceeding with the proposed noncardiac surgery without coronary revascularization. The latter information may not readily be available and the cardiologist consultant and the surgical team will be left to make the best "educated estimate." The best estimate should then be compared with studies such as those of Poldermans *et al.*,[22,24] which showed that patients with positive preoperative dobutamine stress echocardiography who undergo high-risk surgery can have a relatively low 30-day mortality rate of 3.4% and nonfatal MI rate of 0% with perioperative use of a β-adrenergic blocker in the absence of revascularization.

Second, one needs to ascertain that the cardiac risk of the proposed noncardiac surgery will be significantly lowered by prior cardiac intervention, whether by CABG or PTCA. Ideally, the magnitude of reduction in the risk of the noncardiac surgery should be equal to or greater than the risk of cardiac intervention. However, little data are available on the cardiac risk of major noncardiac surgery in patients who have major clinical predictors of cardiac risk or positive noninvasive cardiac tests indicative of the presence of uncorrected CAD and who then undergo the noncardiac surgery without prophylactic coronary revascularization. In one review of 30 patients undergoing urgent or emergent vascular surgeries within 6 weeks of a MI, the cardiac complication rate was 17%.[37] Furthermore, no prospective, randomized, controlled trials have assessed the benefit of prophylactic coronary revascularization, either by CABG or PTCA, in lowering the perioperative cardiac risk of subsequent noncardiac surgery. On the other hand, several retrospective reviews indicate that those who survive CABG may have a reduced cardiac risk at the time of a subsequent noncardiac surgery and that this reduced risk may be comparable with that of those with no CAD.[23,38–41] In the largest such review, Eagle *et al.*[23] showed from a review of 1,961 patients of the Coronary Artery Surgery Study database that prior surgical revascularization is associated with a lower MI (0.8 *vs.* 2.7%) and death rate (1.7 *vs.* 3.3%) in subsequent high-risk noncardiac surgeries, compared with medical therapy alone. Evidence for the benefit of PTCA on subsequent noncardiac surgery is relatively sparse. Allen *et al.*[42] reviewed 148 patients who underwent 193 noncardiac surgeries 4–1,867 days after PTCA and reported only one cardiac death, though four patients died overall. Such data suggests that PTCA may be protective against fatal cardiac events during subsequent noncardiac surgeries.

A third prerequisite of prophylactic coronary revascularization is that its benefit should be realized in such a time frame that the proposed noncardiac surgery is not unduly delayed. Posner *et al.*[43] reported that the risk of adverse cardiac outcomes after noncardiac surgery might be reduced by prior PTCA, but only if the interval between PTCA and the noncardiac surgery was greater than 90 days. Furthermore, Kaluza *et al.*[19] noted that if a noncardiac surgery is performed within 40 days of PTCA with a stent, then the risk of stent thrombosis and death in the perioperative period might be prohibitively high (8 deaths [6 from MI and 2 from major bleeding complications] in 40 patients or 20% mortality in their report). A recent case report also describes a patient who had a cardiac arrest after nephrectomy 32 days after PTCA with stenting and required an emergent PTCA to reopen the thrombosed stent.[44] Intracoronary stents are increasingly used in PTCA and recent technological advances in stenting and antiplatelet regimens have reduced the 30-day stent occlusion rate to as low as 0.5%.[45] Typically, ticlodipine and aspirin are started 3–5 days before PTCA with stenting and continued for 14–30 days, depending on the risk of stent thrombosis. The risk of stent occlusion drops off sharply after the initial 30 days. Major surgery may be associated with activation of the procoagulant system and the risk of stent occlusion may be increased by surgical stresses. What may have been adequate antiplatelet therapy in the nonsurgical period may not prove adequate during the perioperative period. Thus, undergoing a major noncardiac surgery during the early poststenting period poses a significant dilemma in that discontinuation of the antiplatelet therapy increases the risk of stent thrombosis and MI while its continuation, with or without additional anticoagulant regimen such as heparin, increases the risk of major bleeding complications. In summary, the available data suggest that if the proposed noncardiac surgery cannot be delayed for 30 to 40 days after PTCA, then revascularization by PTCA may not be recommended to reduce the cardiac risk.

Regarding the early post-CABG period, Reul *et al.*[46] reported 2.7% cardiac death rate (overall mortality 3.9%) in 255 patients having a simultaneous CABG and a peripheral vascular surgery, 2.2% cardiac death rate (overall mortality 3.6%) in 279 patients having a CABG and then a peripheral vascular surgery 5 days to 3 weeks after CABG within the same hospitalization, and 0% cardiac death rate (0.2% overall mortality) in 559 patients who had a CABG and then a peripheral vascular surgery during a subsequent hospitalization (1 month to 10 yr after CABG). In our review of patients undergoing aortic or peripheral vascular bypass surgeries within a month of CABG (N = 36), their 30-day mortality was 19%, much higher than a historical control of a little over 1% in 4,210 other patients undergoing similar operations ($P < 0.05$).[47] These data suggest that if the patient requires a noncardiac surgery that cannot be delayed 30 days or longer and also has indications for coronary revascularization, performing coronary revascularization either by PTCA or CABG may not result in improved short-term survival. The anesthesiologist or the surgeon may ask a cardiology consultant to help determine whether to proceed with urgent noncardiac surgery with β-adrenergic blockade and consider coronary revascularization afterwards. However, such a determination will be based on the best "educated estimate," rather than literature evidence.

(4) Gender and Cardiology Consultation. The ACC–AHA guidelines were derived from studies in which female patients were grossly underrepresented.[48] Review of the Framingham Heart Study data showed that whereas men and women shared many cardiovascular risk factors, the significance of each factor was different between the genders.[49] Women maintained a lesser probability of CAD at any level of the major cardiovascular risk factors than men did. Thus, what may constitute a major, intermediate, or minor predictor of perioperative cardiac risk for women may be different than for men. For example, whereas unstable angina is classified as a major clinical predictor and stable angina as an intermediate clinical predictor of cardiac risk in the ACC–AHA guidelines, it should be recognized that chest pain is a less reliable indicator of CAD in women. Nonatherosclerotic causes of chest pain such as mitral valve prolapse and coronary artery spasm are believed to be more prevalent in women than in men. Women are approximately three times as likely to have a negative angiogram compared to men, when referred to angiography for chest pain syndromes.[50–52] The chance of an angiographically proven CAD in women with chest pain was less than 7%, if they had less than two risk factors for CAD, but was 55% if more than 2 risk factors were present.[52] In applying the ACC–AHA guidelines (or their modification depicted in fig. 1 of this review), one may need to require that (for example, at step 6 and 7 of fig. 1) women must have multiple intermediate clinical predictors before one considers cardiac testing with cardiology consultation. In addition, in women, history of chest pain that has not been demonstrated to be from CAD may not need to be considered an intermediate clinical predictor, unless multiple risk factors for CAD coexist.

Shacklelford *et al.*[53] performed a retrospective analysis of perioperative cardiac morbidity in 206 patients undergoing elective gynecologic surgery, of whom 168 were postmenopausal. In the postmenopausal subgroup, the Goldman cardiac risk index and the New York Heart Association functional classification were not useful predictors of perioperative cardiac morbidity. Neither were glucose intolerance, cardiac arrhythmia, and estrogen replacement therapy. Useful predictors of cardiac morbidity in this population were hypertension and a history of CAD, proven by previously documented MI, a history of exertional angina lasting more than 15 min responsive to nitrate therapy, or more than 70% occlusion on coronary angiogram. Note that in the ACC–AHA guidelines, uncontrolled hypertension is listed as a minor clinical predictor of risk.[5] If the results of Shackleford *et al.* are duplicated and confirmed in other studies, the significance of hypertension in predicting perioperative cardiac risk may be greater in women than in men. In-hospital mortality rate following MI is higher in women than in men (17.5% *vs.* 12.3%),[54] especially black women (48% mortality at 48 months),[55] and reinfarction rate at 6 months is also higher in women than in men (19% *vs.* 12%).[55] Thus, the significance of an acute MI as a major clinical predictor of perioperative cardiac risk may be even greater in women than in men.

The criteria for a positive exercise stress test were developed for men. A positive exercise stress test in women is more likely to be false positive than in men, whereas a negative test in women who are able to exercise adequately is less likely to be a false negative than in men, mostly because of the lower prevalence of CAD among women.[56] Additional problems with exercise stress testing that have been noted in women include a higher prevalence of electrocardiogram changes due to hyperventilation or position change and a lesser likelihood of exercising to adequate intensity levels owing to comorbid illnesses or general deconditioning.[57] Simple exercise stress test as a preoperative screening test probably does not have a place in the evaluation of women, but should be accompanied by imaging modalities such as stress echocardiography or radionuclide angiography.[48]

(5) Patients with a Severe Valvular Disease. In the ACC–AHA guidelines, a severe valvular disease is considered a major clinical predictor of cardiac risk and should lead to consideration of delay or cancellation of the proposed noncardiac surgery and consideration of cardiac catheterization, echocardiography, and/or possible valve surgery. Several review studies have suggested that in the case of patients with severe aortic stenosis (AS), they may undergo a noncardiac surgery with relative safety, as long as the perioperative care is provided with careful management of the pathophysiological changes associated with AS. O'Keefe *et al.* reported on their experience with 48 patients with severe AS (mean valve area 0.6 cm^2) who were not candidates for, or refused, aortic valve replacement and who needed a noncardiac surgery.[58] There was only one cardiac event with no deaths, for a complication rate of about 2%. This would compare favorably with the 4% mortality rate for aortic valve replacement reported by the Society of Thoracic Surgeons national database*. In a subsequent report of 19 patients with severe AS (mean valve area < 0.5 cm^2), however, the same group reported two perioperative deaths.[59] More recently, Raymer and Yang compared 55 patients with significant AS (mean valve area 0.9 cm^2) with case-matched controls with similar preoperative risk profiles other than AS undergoing similar surgeries.[60] Cardiac complication rates were not significantly different between the groups. Thus patients with severe AS may undergo indicated noncardiac surgery safely, provided that the presence of severe AS is recognized and the patients receive intensive intraoperative and perioperative care with full knowledge of the implications of AS. For the algorithm of figure 1 then, severe AS may be deleted from the list of major clinical predictors. Although a preoperative cardiac consultation may not be indicated for correction of AS, there should be an appropriate follow-up of AS postoperatively.

Data are lacking regarding patients with severe mitral stenosis or severe valvular regurgitation who undergo noncardiac surgery without prior valve surgery. In case of patients with severe idiopathic hypertrophic subaortic stenosis, Haering *et al.* reported that in their review of 77 such patients, there was a relatively high incidence of postoperative CHF (17%), but not of any irreversible cardiac morbidity and mortality.[61]

(6) Consideration of Prohibitive Risks. Any scheme for preoperative cardiac evaluation of patients should include a branch in the decision tree for cancellation of surgery. The ACC–AHA guidelines provide for possible cancellation of surgery in patients with a major clinical predictor of cardiac risk, but the guidelines are not specific concerning when the estimated operative risk is prohibitively high enough that the surgery should no longer be an option even after additional work-up and/or treatment. Such a prohibitive risk may be based on surgical variables and/or the patient's cardiac problems, and this may be an area where the cardiology consultant may help with triage decisions. Identification of factors that point to an extremely high perioperative risk will be important in rational management of medical resources and in assisting the patients and their family with proper planning and acceptance of outcome. Information regarding this issue is sorely lacking.

Summary of Recommendations

Indications for cardiology consultation based on the ACC–AHA guidelines on preoperative cardiac evaluation have been presented, along with a critical review of some of the guideline items. Application of the algorithm requires that the physician initiating the consultation, whether an anesthesiologist or a surgeon, determine whether cardiology consultation is indicated, from considerations of presence or absence of clinical predictors, the patient's functional status, and the risk of the proposed surgery. In general, patients who require an emergent surgery should proceed to surgery with or without a preoperative cardiology consultation and may receive the consultant's input in the postoperative period as needed. For nonemergent noncardiac surgery, cardiology consultation may be indicated (1) for patients with a major clinical predictor of cardiac risk such as unstable coronary syndrome or evolving MI, (2) for patients who are undergoing a high-risk surgery, who have either poor functional status or an intermediate clinical predictor of cardiac risk such as stable angina, history of MI or CHF, diabetes mellitus, or chronic renal failure, and (3) for patients who are undergoing an intermediate-risk surgery, who have both poor functional status and an intermediate clinical predictor, or even in the absence of poor functional status, two or more intermediate clinical predictors. For patients with indications 2 or 3, revascularization within 5 yr or favorable cardiac evaluation within 2 yr with no significant interim changes in symptoms obviates the need for cardiology consultation. Also for these patients, β-adrenergic blockade in the perioperative period may lower their cardiac risk sufficiently. Patients who have been started on a β-adrenergic blockade perioperatively should have an appropriate follow-up with a cardiologist, an internist, or a family physician, so that β-adrenergic blockade may be continued on a long-term basis, if indicated. When a cardiology consultation is obtained, the relative risks and benefits of interventional *versus* medical treatments require investigation. Whenever obtaining cardiology consultation, the physician initiating the consultation should specify the reason for consultation and ask the consultant to delineate the relative risks and benefits of any further diagnostic or therapeutic steps and postoperative follow-up plan.

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