Cardiac risk stratification before noncardiac surgery

STEVEN L. COHN, MD, FACP

Cardiac risk stratification prior to noncardiac surgery can serve a number of goals: (1) to determine the patient's current health status, (2) to establish a surgical-risk profile, (3) to decide whether further cardiac testing is indicated, and (4) to identify actions or recommendations that might reduce the patient's perioperative risk.

This article discusses the elements of cardiac risk evaluation in noncardiac surgical patients, reviews cardiac risk indices and clinical guidelines, surveys options for cardiac testing in preoperative risk assessment, and explores the pros and cons of invasive prophylactic measures to reduce perioperative cardiac risk. Prophylactic medical therapy is discussed in the next article in this supplement.

This discussion applies, of course, to patients undergoing nonurgent surgery. For patients undergoing urgent nonelective surgery, preoperative risk assessment is moot because there is little time to perform testing and the results are not likely to influence the surgical approach. In fact, no test should be performed unless the result will change patient management.

DETERMINING CURRENT HEALTH STATUS

Health interview

The most important element of cardiac risk evaluation is the health interview because information on the patient's history and current status will serve as the basis for most of our decisions and actions.

History. A history of cardiovascular disease—particularly myocardial infarction (MI), angina, congestive heart failure (CHF), arrhythmia, or valvular disease—is obviously significant. In such cases, ascertain the type of diagnostic and therapeutic procedures the patient has already undergone, when and where they were performed, and the specific results.

There is little value to knowing that the results of a previous test were "okay." With regard to stress testing, we need specific information on, for example, the patient's peak heart rate, peak systolic pressure, and rate pressure product (RPP). The "ischemic threshold" is a very reproducible value in an individual patient. It is important to anesthesiologists because a patient is less likely to experience ischemia during surgery if the anesthesiologist can keep the RPP from exceeding this threshold. If the patient previously underwent a thallium stress test, we need to know about any reperfusion abnormalities, including the number of segments involved and their distribution. Important findings on echocardiography include wall-motion abnormalities, ejection fraction, and valvular anatomy and function. If the patient has undergone cardiac catheterization, knowledge of the presence of left main coronary artery disease or triple-vessel disease is not only vital before surgery but is also an independent indication for revascularization even if surgery had not been planned. Finally, we need to know if the patient has undergone revascularization procedures.

Current medical status. Significant risk factors for cardiac disease are diabetes, hypertension, hyperlipidemia, and cigarette smoking. The presence of other concomitant conditions—eg, peripheral vascular disease, cerebrovascular disease, chronic renal insufficiency, and chronic obstructive pulmonary disease (COPD)—may place patients at a higher risk for cardiac disease and perioperative complications than they otherwise would be.

Another important issue is the patient's functional status. Key factors include chest pain and shortness of breath as well as the patient's functional capacity. I specifically ask patients how many blocks they can walk and how many flights of stairs they can climb

From the the Division of General Internal Medicine, SUNY Downstate Medical Center, Brooklyn, NY.

Address: Steven L. Cohn, MD, Chief, Division of General Internal Medicine, SUNY Downstate Medical Center, 450 Clarkson Avenue, Box 68, Brooklyn, NY 11203; steven.cohn@downstate.edu.

Disclosure: Dr. Cohn reported that he has no financial interests or affiliations that pose a potential conflict of interest with this article.

Downloaded from www.ccjm.org on May 10, 2025. For personal use only. All other uses require permission.

without stopping. Do not underestimate the severity of risk in home-bound patients who report no chest pain or shortness of breath; the amount of stress that they will experience during surgery (other than a minor procedure) will probably exceed the amount they exert during activities of daily living.

Age. Age may serve as a marker for decreased cardiac reserve or subclinical disease, but by itself has only minor significance.

Physical examination

If the patient provides thorough and honest answers during the health interview, the typical physical examination will usually serve only to confirm what is already known about the patient's current status. Potentially important findings include the following:

- Vital signs (arrhythmias, uncontrolled hypertension)
- A murmur (aortic stenosis, in particular)
- A third heart sound, jugular venous distention, or rales (heart failure).

Electrocardiography

Electrocardiography (ECG) is typically performed prior to surgery, but it rarely changes the management approach. For example, detecting a conduction defect, bundle branch block, left ventricular hypertrophy, or nonspecific changes in ST-T waves on ECG will not have any impact on surgical decisions. Finding Q waves in a patient with a history of an MI only confirms it. At best, an ECG will detect evidence of a recent silent MI, but this is rare. Finally, most arrhythmias are discovered on physical examination prior to ECG.

RISK STRATIFICATION

Based on the history, physical examination, and ECG, patients can be categorized as being in a low-risk, intermediate-risk, or high-risk group.

High-risk patients should be considered for further therapy and evaluation, including invasive testing. A noninvasive test in such a patient often adds little to what is already known. Moreover, a negative result on a noninvasive test is not as reliable in a high-risk patient because the result is more likely to be a false negative in this setting.

Intermediate-risk patients are numerous and their risk can be refined either up or down depending on the rigor of further evaluation. One option for such patients is additional testing; another is to proceed with surgery after initiating a trial of prophylactic medical therapy.

Low-risk patients can proceed to surgery without any further cardiac evaluation.

PUBLISHED GUIDELINES

Many cardiac risk indices and recommendations have been published over the years, but the most prominent are the guidelines developed jointly by the American College of Cardiology and the American Heart Association (ACC/AHA) in 1996[1] (and updated in 2002[2]), guidelines published by the American College of Physicians (ACP) in 1997,[3] and the Revised Cardiac Risk Index.[4]

ACC/AHA guidelines

These guidelines[1] were generally built around three major considerations in assessing risk: (1) the patient's clinical predictors, (2) the patient's functional capacity, and (3) the individual risks of specific types of surgery (Figure 1).

Clinical predictors. The three classifications of clinical predictors are major, intermediate, and minor. Most patients have intermediate or minor predictors.

Major clinical predictors are unstable coronary syndromes (including a recent [< 30 days] MI or class III or IV angina), decompensated CHF, significant arrhythmias, and severe valvular disease. (Note that the ACC/AHA defines "recent" as within 30 days, unlike older guidelines in which the time frame ranges from 3 to 6 months. The reason for this change is that now most patients with a recent MI routinely undergo various tests to stratify risk or therapeutic interventions during their hospitalization for the MI.) Patients with major clinical predictors should probably not undergo any elective surgery without further evaluation and treatment, be it angiography and revascularization, noninvasive testing, or just medical therapy and risk factor modification.

Intermediate clinical predictors include class I or II angina, a history of MI beyond the preceding 30 days, compensated or previous CHF, diabetes, and chronic renal insufficiency. Patients with intermediate predictors should be evaluated for exercise capacity by assessment of metabolic equivalents (METs) for oxygen consumption (Table 1). Patients undergoing low-risk surgical procedures do not require any further testing; however, a low METs score (≤ 4) indicates a potential need for noninvasive testing prior to intermediate- or high-risk surgeries. Further assessment of patients with a moderate or good score depends on the degree of surgical risk.

Downloaded from www.ccjm.org on May 10, 2025. For personal use only. All other uses require permission.

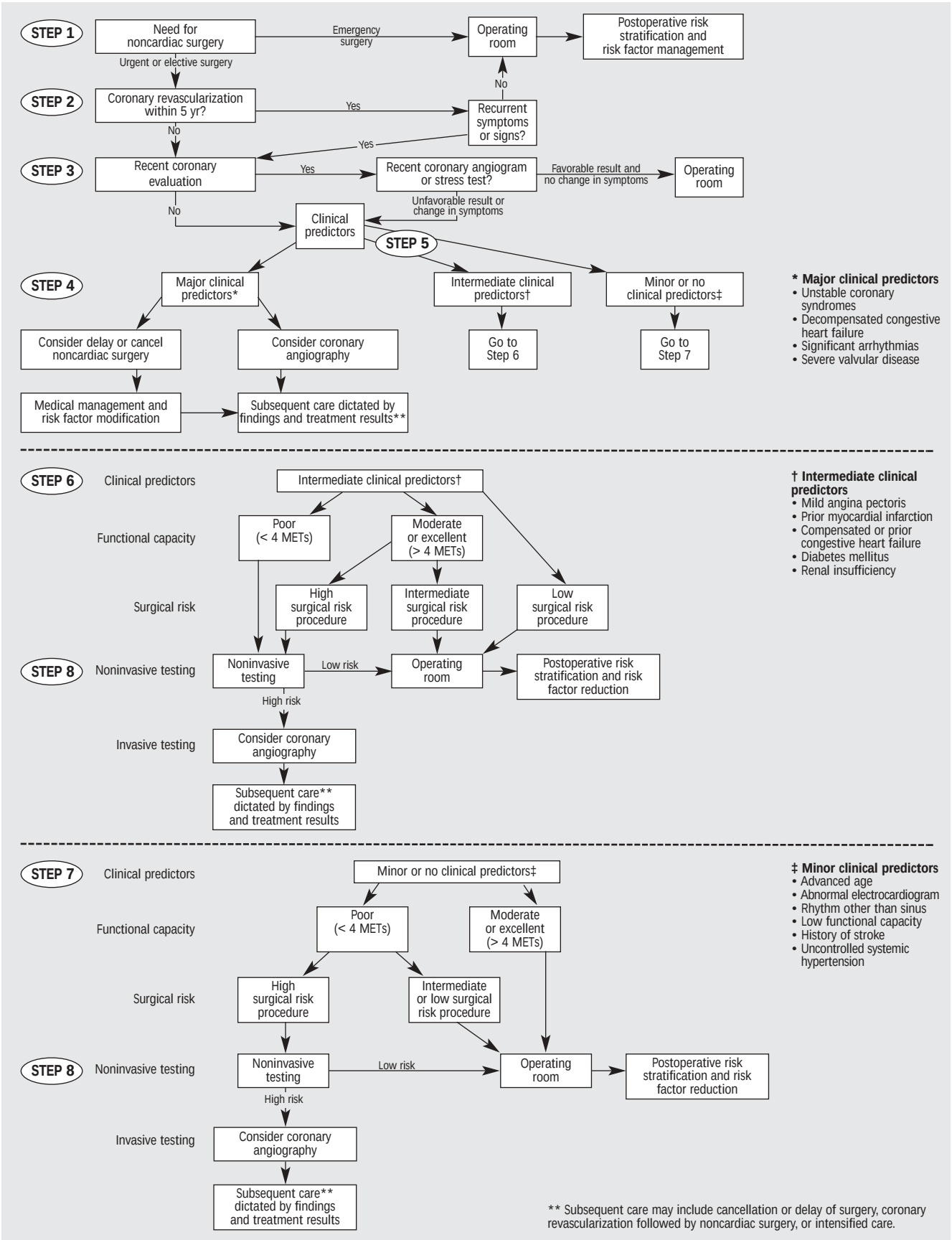

FIGURE 1. Stepwise approach to preoperative cardiac assessment. METs = metabolic equivalents. Reprinted from reference 2, copyright 2002, with permission from the American College of Cardiology Foundation.

Downloaded from www.ccjm.org on May 10, 2025. For personal use only. All other uses require permission.

Minor clinical predictors are advanced age, nonspecific ECG abnormalities, nonsinus rhythm, cerebrovascular disease, and uncontrolled hypertension. Patients with minor predictors also should undergo a METs assessment. Those with a moderate or good score can proceed to surgery, while others may or may not be candidates for noninvasive testing or medical therapy, depending on the surgical risk.

Surgery-specific risk. Different types of surgery are classified simply as high-, intermediate-, and low-risk.

High-risk surgeries are those associated with a predicted cardiac complication rate greater than 5%. These include major emergency surgery, procedures to correct aortic disease or significant peripheral vascular disease, and other prolonged procedures that involve significant fluid shifts, fluid administration, or blood loss. Most patients undergoing high-risk surgery should either undergo noninvasive testing or receive medical therapy, depending on their clinical predictors.

Intermediate-risk surgeries (expected cardiac complication rate of 1% to 5%) include carotid endarterectomy (which is classified separately from other vascular procedures because newer surgical techniques have lowered its risk), major head and neck operations, major joint replacement, repair of hip fracture, and intraperitoneal, intra-abdominal, and intrathoracic procedures. Open or radical prostatectomies are included in this list. Patients with adequate functional capacity (and no major clinical predictor) can undergo intermediate-risk surgery without further testing.

Low-risk surgeries (expected cardiac complication rate < 1%) are those that do not involve invasion of a body cavity, such as endoscopic procedures and superficial excisions. The risk of complications associated with these procedures is generally lower than the risk of preoperative cardiac testing and subsequent intervention, so adherence to the dictum "first do no harm" calls for allowing patients to proceed to these types of surgeries without testing.

Exercise capacity. The METs classification is used to determine exercise capacity. It is a fairly subjective evaluation. I consider a patient to be at risk if he or she cannot perform tasks that are assigned a METs value of 4 or less (Table 1). I generally ask patients how many blocks they can walk and how many flights of stairs they can climb without stopping. I consider patients to be at low (or at least acceptable) risk if they can walk at least three blocks and climb one flight of stairs without difficulty.

However, patient self-reports of exercise capacity are not always reliable, so when there is doubt, you can walk the patient up and down the hall or stairs to see firsthand what the patient can do.

TABLE 1
Estimated energy requirements for various activities

• 1 MET	• 4 METs
– Take care of self	– Climb 1 flight, go uphill
– Eat, dress, toilet	– Walk on level ground 4 mph
– Walk indoors	– Do heavy housework (scrub floors, move furniture)
– Walk 1 to 2 blocks (level) at 2 to 3 mph	– Do moderate recreational activities
– Do light work around the house (dust, wash dishes)	– Participate in strenuous sports
• 4 METs	• ≥ 10 METs

MET = metabolic equivalent

Reprinted from reference 1, copyright 1996, with permission from the American College of Cardiology Foundation.

ACC guideline shortcut for noninvasive testing. In general, noninvasive testing is indicated in the presence of two of the following three negative factors: intermediate or major clinical predictors, high-risk surgery, and poor exercise capacity.

ACP guidelines

The two main elements of the ACP guidelines[3] are the Detsky modified cardiac risk index and a list of "low-risk variables." Patients are first evaluated according to the Detsky criteria, and if they are found not to be at high risk, they are then evaluated according to the low-risk variables criteria.

Detsky index. This cardiac risk index was developed by Detsky et al and published in 1986.[5] A score of 20 points or more indicates high risk; point values are assigned for each of the following conditions:

- MI within 6 months (10 points)
- MI more than 6 months earlier (5)
- Class III angina (10)
- Class IV angina (20)
- Alveolar pulmonary edema within the previous week (10) or ever (5)
- Suspected aortic stenosis (20)
- Arrhythmias (5)
- Poor general medical condition (5)
- Age greater than 70 years (5)
- Surgery on an emergency basis (10).

Low-risk variables. "Low-risk variables" is a confusing term because the presence of these variables

Downloaded from www.ccjm.org on May 10, 2025. For personal use only. All other uses require permission.

actually indicates *higher* risk; it is the *absence* of these variables that indicates low risk.

There is significant overlap between the sets of so-called low-risk variables. Both Eagle et al[6] and Vanzetto et al[7] included in their lists age greater than 70 years, a history of angina, the presence of diabetes, and demonstration of Q waves on ECG. In addition, Eagle et al included a history of ventricular ectopy, and Vanzetto et al included a history of MI, demonstration of ST-segment ischemic abnormalities on resting ECG, hypertension with severe left ventricular hypertrophy, and a history of CHF.

Patients with fewer than 20 Detsky points who have 0 or 1 low-risk variable are considered to be at low risk (< 3% chance of complications), and those with 2 or more variables are considered to be at intermediate risk (3% to 15% chance of complications).

Evaluation steps. Patients who are young, who are undergoing minor surgery, who have no systemic disease, and who require emergency surgery can go directly to the operating room without further testing. For other patients, the next step is to incorporate the Detsky index. A Detsky score of 20 or more is comparable to a major clinical predictor in the ACC/AHA scheme, and it is an indication for further evaluation or treatment prior to surgery.

However, most patients have a Detsky score of 15 points or less, and at this point we consider the aforementioned low-risk variables. Patients with none or only one of these variables can proceed directly to surgery without testing. Likewise, patients with two or more low-risk variables who are undergoing *nonvascular* surgery require no further testing, but those with two or more low-risk variables who are scheduled for *vascular* surgery should undergo further noninvasive testing with either dipyridamole-thallium imaging or dobutamine stress echocardiography; also, we should determine their eligibility for beta-blocker therapy if needed. Patients whose imaging results are negative can proceed to surgery, but those with positive results are considered high-risk.

Once a patient is classified as high-risk (> 15% chance of complications) at any point during the evaluation process, we must postpone surgery until we determine the nature of the risk. Patients who have ischemic heart disease should be evaluated to determine if they are suitable candidates for coronary revascularization. If so, reevaluate after revascularization; if not, consider switching to a less risky procedure or canceling surgery.

Patients whose high risk is associated with CHF, arrhythmia, valvular disease, or modifiable risk factors should undergo a trial of optimal medical management and subsequent reassessment of their cardiovascular risks. Again, if optimal treatment or risk factor modification fails, consider switching to a less risky procedure or canceling surgery.

Differences between the ACC/AHA and ACP guidelines

The ACP guidelines are purely evidence-based; without evidence, the ACP makes no recommendation. The ACC/AHA, on the other hand, uses the best evidence available; when evidence is insufficient or lacking, it relies on expert consensus panels to make recommendations. Also, the ACP does not consider exercise capacity and the ACC/AHA does. Likewise, the ACC/AHA uses surgery-specific risk while the ACP divides surgery into vascular and nonvascular categories. In sum, the ACC/AHA tends to recommend more testing than does the ACP.

Other risk assessment systems

In 1999, Lee et al described their simple index, the Revised Cardiac Risk Index, which is based on a study of more than 4,000 patients aged 50 years or older who had undergone major elective noncardiac surgery.[4] They identified six independent predictors of major cardiac complications: (1) high-risk surgery, (2) preoperative treatment with insulin, (3) preoperative serum creatinine level greater than 2 mg/dL, (4) history of ischemic heart disease, (5) history of CHF, and (6) history of cerebrovascular disease.

An absence of these risk factors was associated with a 0.4% to 0.5% risk of a major cardiac complication, and the presence of one risk factor carried a risk of 0.9% to 1.3% (low risk in both cases). The risk was 4% to 7% for patients with two risk factors (intermediate risk) and 9% to 11% for those with three or more risk factors (high risk).

The shortcoming of this system is that the authors did not make any specific recommendations as to what to do with this information; however, subsequent publications did use this index in an algorithm with beta-blockers,[8] as discussed in the next article in this supplement.

In 2005, Kertai et al published their "customized" version of the Revised Cardiac Risk Index,[9] which is based on a point total similar to that used for the Detsky index. The Kertai system is different in that it also subtracts points for use of prophylactic medical therapy (beta-blockers and statins).

NONINVASIVE TESTING

Once the risk assessment indicates that further testing is advisable, the next step is to decide which tests are

Downloaded from www.ccjm.org on May 10, 2025. For personal use only. All other uses require permission.

appropriate. Noninvasive testing is usually the preferred first step. The common noninvasive tests are resting two-dimensional echocardiography, exercise stress testing with or without imaging, pharmacologic stress testing with nuclear imaging, and pharmacologic stress testing with echocardiography. Some are more useful than others.

Echocardiography

An ejection fraction of less than 35% may predict postoperative CHF, but it is not a consistent predictor of ischemic events. Therefore, resting two-dimensional echocardiography should not be used preoperatively to evaluate CAD. It might be helpful in a patient with CHF or suspected valvular disease, but it usually does not provide any useful information beyond what we already know clinically.

Exercise stress testing

The dynamic tests measure a patient's functional capacity, which can be impaired by old age, deconditioning, myocardial ischemia, and decreased cardiac or pulmonary reserve. One problem with ordering an exercise test is that we do not know whether the cause of functional impairment is cardiac or noncardiac. Another problem is that most patients cannot complete the test; fewer than half of tested patients reach their target heart rate, so their results are inconclusive. Ischemia at a low level of exercise, however, is significant.

Pharmacologic stress testing with nuclear imaging

Most of these tests use a dipyridamole stressor and thallium contrast. The endpoints are the size and number of reperfusion defects; fixed defects are less important for short-term prognosis. The negative predictive value is good (> 95%), but the positive predictive value is poor (4% to 20%).[2,10] These tests should not be used in patients with COPD, as dipyridamole may cause bronchospasm, but they are preferred over exercise and dobutamine stress testing for patients with left bundle branch block because the other modalities can yield false-positive results.

Pharmacologic stress testing with echocardiography

These tests are usually performed with dobutamine as a stressor to identify wall-motion abnormalities. The use of dobutamine more closely simulates true exercise in that it increases oxygen demand. Evidence of ischemia at low doses of dobutamine usually indicates more severe disease. Again, the negative predictive value is good (> 93%), but the positive predictive value for serious events is low (7% to 25%).[2,10]

INVASIVE PROCEDURES

Positive findings on noninvasive testing call for prophylactic measures—either a trial of medical therapy (discussed in the next article in this supplement) or an invasive procedure.

Prophylactic CABG. Keep in mind the fact that coronary artery bypass graft surgery (CABG) carries significant risks of its own. Among patients overall, the average risk of perioperative mortality during CABG is about 1% to 2%,[11] the risk of nonfatal MI is 2% to 5%,[12] and the risk of stroke is 1% to 3%.[13] These rates, of course, are higher in high-risk surgical patients.

Nevertheless, observational studies over the years have shown that previous CABG was associated with a lower rate of mortality and nonfatal MI during noncardiac surgery. Among all patients who underwent noncardiac surgery, perioperative mortality was 0.9% for those who had previously undergone CABG and 2.4% for those who had not. The corresponding rates for patients who underwent high-risk noncardiac surgery were 1.7% and 3.3%. Rates of nonfatal MI were 0.7% vs 1.1% overall and 0.8% vs 2.7% during high-risk noncardiac surgery. The protective effect of CABG lasted approximately 4 to 6 years. There was no benefit with CABG in those patients who subsequently underwent a low-risk noncardiac procedure.[14,15]

Percutaneous coronary intervention. Likewise, it appears that percutaneous coronary intervention (PCI) may also lower the risk of perioperative mortality and nonfatal MI (compared with historical controls). Studies suggest that noncardiac surgery should be performed no sooner than 7 to 10 days after balloon angioplasty[16] and no sooner than 4 to 6 weeks after coronary stent placement.[17–20] However, the prophylactic benefit of placing stents is questionable. A compilation of results from four studies using bare metal stents showed that despite preoperative stenting, complication rates with subsequent noncardiac surgery were high: mortality, 6.9%; nonfatal MI, 5.4%; and hemorrhage, 6.9%.[17–20] Likewise, drug-eluting stents may not be advisable prior to noncardiac surgery because they delay endothelialization and may require a longer period of dual-antiplatelet therapy (at least 2 to 3 months for sirolimus-coated stents and 6 months for paclitaxel-coated stents).

CABG-PCI study. A multicenter Veterans Administration study of men who underwent prophylactic preoperative CABG or PCI showed that coronary artery revascularization before elective vascular surgery in patients with *stable* cardiac symptoms did not significantly alter outcome.[21] A few study limita-

Downloaded from www.ccjm.org on May 10, 2025. For personal use only. All other uses require permission.

tions notwithstanding, including the fact that both groups were treated with intensive medical therapy, the authors could not recommend prophylactic revascularization. On the other hand, revascularization may be appropriate for patients with unstable or more severe cardiac symptoms.

Pulmonary artery catheterization. Although pulmonary artery catheterization might detect hemodynamic disorders that could lead to a change in treatment, there is no evidence that it prevents perioperative cardiac morbidity or mortality.[22] It might benefit the type of patients who are usually excluded from these clinical trials—eg, those with a recent MI, pulmonary edema, CHF, chronic kidney disease, or valvular disease—who undergo major surgery.

SUMMARY

The history and the physical examination remain the most important elements in cardiac risk stratification of patients prior to noncardiac surgery. Indications for further cardiac tests and interventions are usually the same as in the nonsurgical setting. No test should be performed unless the results will affect patient management. In many cases, noninvasive testing is being replaced by prophylactic medical therapy, a topic explored in the next article in this supplement.

REFERENCES

1. Eagle KA, Brundage BH, Chaitman BR, et al. Guidelines for perioperative cardiovascular evaluation for noncardiac surgery. Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). J Am Coll Cardiol 1996; 27:910–948.
2. Eagle KA, Berger PB, Calkins H, et al; American College of Cardiology; American Heart Association. ACC/AHA guideline update for perioperative cardiovascular evaluation for noncardiac surgery—executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1996 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). J Am Coll Cardiol 2002; 39:542–553.
3. American College of Physicians. Guidelines for assessing and managing the perioperative risk from coronary artery disease associated with major noncardiac surgery. Ann Intern Med 1997; 127:309–312.
4. Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation 1999; 100:1043–1049.
5. Detsky AS, Abrams HB, McLaughlin JR, et al. Predicting cardiac complications in patients undergoing non-cardiac surgery. J Gen Intern Med 1986; 1:211–219.
6. Eagle KA, Coley CM, Newell JB, et al. Combining clinical and thallium data optimizes preoperative assessment of cardiac risk before major vascular surgery. Ann Intern Med 1989; 110:859–866.
7. Vanzetto G, Machecourt J, Blendea D, et al. Additive value of thallium single-photon emission computed tomography myocardial imaging for prediction of perioperative events in clinically selected high cardiac risk patients having abdominal aortic surgery. Am J Cardiol 1996; 77:143–148.
8. Auerbach AD, Goldman L. Beta-blockers and reduction of cardiac events in noncardiac surgery: scientific review. JAMA 2002; 287:1435–1444.
9. Kertai MD, Boersma E, Klein J, et al. Optimizing the prediction of perioperative mortality in vascular surgery by using a customized probability model. Arch Intern Med 2005; 165:898–904.
10. Cohn SL, Goldman L. Preoperative risk evaluation and perioperative management of patients with coronary artery disease. Med Clin North Am 2003; 87:111–136.
11. Peterson ED, Coombs LP, DeLong ER, et al. Procedural volume as a marker of quality for CABG surgery. JAMA 2004; 291:195–201.
12. Chaitman BR, Alderman EL, Sheffield LT, et al. Use of survival analysis to determine the clinical significance of new Q waves after coronary bypass surgery. Circulation 1983; 67:302–309.
13. Roach GW, Kanchuger M, Mangano CM, et al. Adverse cerebral outcomes after coronary bypass surgery. Multicenter Study of Perioperative Ischemia Research Group and the Ischemia Research and Education Foundation Investigators. N Engl J Med 1996; 335:1857–1863.
14. Eagle KA, Rihal CS, Mickel MC, et al. Cardiac risk of noncardiac surgery: influence of coronary disease and type of surgery in 3368 operations. CASS Investigators and University of Michigan Heart Care Program. Coronary Artery Surgery Study. Circulation 1997; 96:1882–1887.
15. Eagle KA, Guyton RA, Davidoff R, et al. ACC/AHA 2004 guideline update for coronary artery bypass graft surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1999 Guidelines for Coronary Artery Bypass Graft Surgery). Circulation 2004; 110:e340–e437.
16. Elmore JR, Hallett JW Jr, Gibbons RJ, et al. Myocardial revascularization before abdominal aortic aneurysmorrhaphy: effect of coronary angioplasty. Mayo Clin Proc 1993; 68:637–641.
17. Kaluza GL, Joseph J, Lee JR, Raizner ME, Raizner AE. Catastrophic outcomes of noncardiac surgery soon after coronary stenting. J Am Coll Cardiol 2000; 35:1288–1294.
18. Sharma AK, Ajani AE, Hamwi SM, et al. Major noncardiac surgery following coronary stenting: when is it safe to operate? Cathet Cardiovasc Interv 2004; 63:141–145.
19. Wilson SH, Fasseas P, Orford JL, et al. Clinical outcome of patients undergoing non-cardiac surgery in the two months following coronary stenting. J Am Coll Cardiol 2003; 42:234–240.
20. Reddy PR, Vaitkus PT. Risks of noncardiac surgery after coronary stenting. Am J Cardiol 2005; 95:755–757.
21. McFalls EO, Ward HB, Moritz TE, et al. Coronary-artery revascularization before elective major vascular surgery. N Engl J Med 2004; 351:2795–2804.
22. Polanczyk CA, Rohde LE, Goldman L, et al. Right heart catheterization and cardiac complications in patients undergoing noncardiac surgery: an observational study. JAMA 2001; 286:309–314.

Downloaded from www.ccjm.org on May 10, 2025. For personal use only. All other uses require permission.