

H CONT. may decrease the probability of postoperative pneumonia and venous thromboembolism (VTE).

Malnutrition is a risk factor for perioperative morbidity, including infection and poor wound healing, and several nutrition risk stratification tools are available to identify patients at risk for postoperative complications related to malnutrition. The Subjective Global Assessment of Nutritional Status tool incorporates history of calorie intake and physical examination findings, whereas the Nutritional Risk Screening Tool relies on age, BMI and weight loss, and severity of the current medical condition. Serum protein markers, including albumin and prealbumin, are also predictive of postoperative complications. Loss of 15% of body weight over 6 months and a serum albumin level less than 3.0 g/dL (30 g/L) are the most predictive factors of poor surgical outcomes related to malnutrition. Notably, increased enteral calorie intake is effective in reducing postoperative complications.

ERAS programs use evidence-based protocols to standardize care, improve outcomes, and reduce costs in postoperative patients. Best studied in patients undergoing colorectal surgery, ERAS interventions include optimization of nutritional status, physical conditioning, abstinence from alcohol and tobacco, postoperative mobilization, and early removal of urinary catheters. ERAS programs have been demonstrated to decrease length of hospital stay and result in earlier mobilization and return of bowel function in colorectal surgery populations. They are currently being implemented and studied in other surgical populations.

Common complications in the postoperative setting include postoperative urinary retention (POUR), postoperative ileus, and postoperative nausea and vomiting (PONV). POUR is characterized by incomplete bladder emptying after surgery, resulting in increased postvoid residual urine volume. Risk factors include type of surgery (incontinence and anorectal surgery, hernia repair, joint arthroplasty), longer surgery, use of regional anesthesia, administration of more than 750 mL of intraoperative fluids, use of certain postoperative medications (opioids, anticholinergic agents), older age, constipation, pelvic organ prolapse, neurologic disease, history of urinary retention, and history of pelvic surgery. POUR is a urologic emergency. Reversible causes of POUR, such as medication use, should be addressed. In patients with benign prostatic hyperplasia, α_2 -blockers should be continued, whereas medications with associated anticholinergic effects, such as oxybutynin, should be withheld. Early removal of indwelling catheters and voiding trials are recommended. For patients in whom a voiding trial is unsuccessful, clean intermittent catheterization is indicated. Urinary tract obstruction should be excluded if POUR is persistent.

Postoperative ileus, or gastrointestinal hypomotility after surgery, is associated with increased length of hospital stay. Ileus is often a physiologic response related to sympathetic nervous system activation, although it can also be caused by activation of inflammatory mediators or the use of medications, such as anesthetics and opioids. Risk factors for the

development of postoperative ileus include abdominal and pelvic surgery, open surgical technique, and the presence of other postoperative complications, such as pneumonia. Treatment of ileus includes minimization of postoperative opioids, adequate hydration, bowel rest, electrolyte repletion, postoperative ambulation, and use of chewing gum. Preventive measures for ileus include an appropriate postoperative bowel regimen, which may comprise fiber, stool softeners, osmotic laxatives, and stimulant laxatives. Few data from well-designed clinical trials are available to guide therapy for prolonged postoperative ileus, typically defined as ileus lasting longer than 3 to 5 days. In these patients, it is important to distinguish postoperative ileus from mechanical bowel obstruction.

The prevention and treatment of PONV, a common postoperative event that results in significant patient distress, require a multifaceted approach that involves identifying at-risk patients, reducing baseline risk factors, providing prophylaxis, and treating symptoms. Risk factors for PONV include female sex; young age; nonsmoking status; and use of general anesthesia, postoperative opioids, or volatile anesthetics. Although many risk-mitigation strategies include intraoperative and immediate postoperative care, the internist plays an important role in ensuring adequate postoperative hydration, minimizing the use of opioids, and providing pharmacologic antiemetic therapy. **H**

KEY POINTS

- Preoperative laboratory testing should be performed based on the patient's medical conditions, physical examination findings, and preoperative symptoms; routine laboratory panels expose patients to unnecessary testing and are not recommended. **HVC**
- There is a paucity of high-quality evidence to guide perioperative medication management; in general, most medications are tolerated throughout the perioperative period.
- Optimization of nutritional status, early mobilization, use of lung expansion modalities, and enhanced recovery after surgery programs are important components of the postoperative care plan. **HVC**
- Treatment of postoperative ileus includes minimization of postoperative opioids, adequate hydration, bowel rest, electrolyte repletion, postoperative ambulation, and use of chewing gum.

Cardiovascular Perioperative Management

Cardiovascular Risk Assessment

Preoperative cardiac evaluation entails assessment of patient-specific risk, surgery-specific risk, and urgency of surgery (emergent, urgent, or time sensitive). The approach recommended by the American College of Cardiology (ACC)/American Heart Association (AHA) for perioperative cardiovascular



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evaluation in patients undergoing noncardiac surgery is presented in **Figure 29**.

Risk calculators, including the Revised Cardiac Risk Index (**Table 92**) and American College of Surgeons National Surgical Quality Improvement Program myocardial infarction and cardiac arrest calculator (<https://riskcalculator.facs.org/RiskCalculator>), can be used to determine the risk for a perioperative major adverse cardiac event (MACE). Both risk calculators incorporate patient- and surgery-specific risk factors.

Patients with low risk (<1% risk of perioperative MACE) may proceed to surgery without preoperative cardiac stress testing, whereas patients with elevated risk (≥1% risk for perioperative MACE) should undergo assessment of functional capacity. Metabolic equivalents (METs) are used to represent the patient's functional capacity based on the intensity of activity able to be performed. If the patient's functional capacity exceeds 4 METs, the patient may proceed to surgery without further testing. Examples of activities that require 4 METs include walking 4 miles per hour on a flat surface; climbing one to two flights of stairs without stopping; or performing vigorous housework, such as vacuuming. Cardiac stress testing should be considered in patients at elevated risk for MACE

with a functional capacity of less than 4 METs or if functional capacity cannot be determined, but only if the results of stress testing will change perioperative management.

Preoperative electrocardiography (ECG) is reasonable in patients with known coronary artery disease, arrhythmia, peripheral artery disease, cerebrovascular disease, or structural heart disease undergoing moderate- to high-risk surgeries. Preoperative ECG may be considered for other asymptomatic patients except those undergoing low-risk procedures. ECG may not alter preoperative decision making, but it provides a useful baseline to guide postoperative management in the event of complications.

Echocardiography to evaluate left ventricular function should not be routinely performed preoperatively. Echocardiography is recommended in certain clinical scenarios, such as in the presence of dyspnea of unknown origin, heart failure with worsening dyspnea or overall change in clinical status, known left ventricular dysfunction without echocardiographic assessment in the last year, and known or suspected moderate to severe valvular stenosis or regurgitation without echocardiographic assessment in the last year or with a change in clinical status.

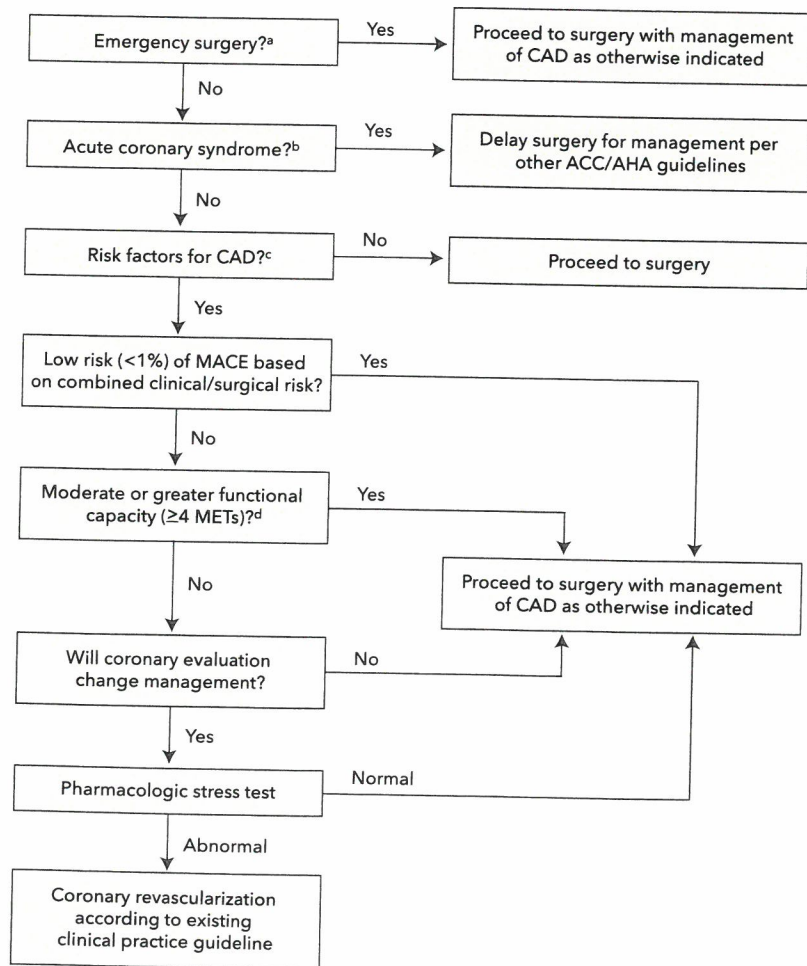


FIGURE 29. Perioperative ischemic cardiac disease evaluation for noncardiac surgery.

ACC = American College of Cardiology; AHA = American Heart Association; CAD = coronary artery disease; MACE = major adverse cardiac event; METs = metabolic equivalents.

^aEmergency surgery required within 6 hours to avoid loss of life or limb.

^bAcute coronary syndromes: myocardial infarction <30 days ago, unstable or severe angina.

^cRisk factors for CAD: not specifically defined in ACC/AHA guidelines; examples include known CAD, cerebrovascular disease (i.e., stroke or transient ischemic attack), chronic kidney disease, diabetes mellitus, and heart failure.

^dExamples of activities requiring ≥4 METs include climbing a flight of stairs, walking up a hill, walking on level ground at 4 miles per hour, running for a short distance, and playing tennis.

Recommendations from Fleisher LA, Fleischmann KE, Auerbach AD, Barnason SA, Beckman JA, Bozkurt B, et al; American College of Cardiology. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. *J Am Coll Cardiol.* 2014;64:e77-137. [PMID: 25091544] doi:10.1016/j.jacc.2014.07.944

TABLE 92. Revised Cardiac Risk Index and Predicted Rate of Major Cardiac Complications Perioperatively

Risk Factor (1 point for each)	
High-risk surgery (intrathoracic, intraperitoneal, suprainguinal vascular)	
Ischemic heart disease	
Heart failure (compensated)	
Diabetes mellitus (requiring insulin)	
Cerebrovascular disease	
Chronic kidney disease (serum creatinine >2.0 mg/dL [176.8 μmol/L]) ^a	
Number of Points	Risk for Major Cardiac Complications ^b
0	0.4% (95% CI, 0.1-0.8)
1	1.0% (95% CI, 0.5-1.4)
2	2.4% (95% CI, 1.3-3.5)
≥3	5.4% (95% CI, 2.8-7.9)

^aEstimated glomerular filtration rate <30 mL/min/1.73 m² also shown to predict cardiovascular risk.

^bDefined as cardiac death, nonfatal myocardial infarction, and nonfatal cardiac arrest.

Data from 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(10):1043-9. [PMID: 10477528] and Devereaux PJ, Goldman L, Cook DJ, Gilbert K, Leslie K, Guyatt GH. Perioperative cardiac events in patients undergoing noncardiac surgery: a review of the magnitude of the problem, the pathophysiology of the events and methods to estimate and communicate risk. *CMAJ*. 2005;173:627-34. [PMID: 16157727]

postoperative troponin levels and an ECG in asymptomatic patients. However, these tests are recommended in patients with signs or symptoms of myocardial ischemia, which often presents atypically in the postoperative period (including as delirium in the elderly, hyperglycemia, and blood pressure fluctuations).

Heart Failure

Medical management of decompensated heart failure should be optimized before surgery and may involve diuresis, fluid restriction, and medication adjustments (see MKSAP 18 Cardiovascular Medicine).

Cardiac Arrhythmias

Risk management strategies for patients with a cardiac arrhythmia who are undergoing surgery include continuation of antiarrhythmic medications and, for some patients, continuous cardiac monitoring.

Patients with atrial fibrillation are at risk for rapid ventricular rate due to surgical stress, fluid shifts, and postoperative pain. Maintaining euolemia, optimizing postoperative pain management, and controlling rates with medications are all appropriate strategies in stable patients. Hemodynamically unstable patients should undergo direct-current cardioversion.

A cardiologist should be consulted in patients with an implantable cardioverter-defibrillator who are undergoing surgery. Patients in whom a device has been deactivated for surgery should undergo continuous cardiac monitoring until the device is reprogrammed.

Valvular Heart Disease

The ACC/AHA guideline states that it is reasonable to perform elevated-risk elective noncardiac surgery in patients with severe asymptomatic aortic stenosis, mitral regurgitation, or aortic regurgitation with preserved left ventricular function. In patients who are candidates for valvular intervention due to symptoms or severity of disease, valvular intervention should be performed before elective noncardiac surgery.

Pulmonary Hypertension

Preoperative evaluation by a pulmonary hypertension specialist is advised for patients with pulmonary hypertension with high-risk features, including group 1 pulmonary hypertension (pulmonary arterial hypertension), pulmonary arterial systolic pressure greater than 70 mm Hg, moderate or severe right ventricular systolic dysfunction, and New York Heart Association functional class III or IV symptoms attributable to pulmonary hypertension. Patients with pulmonary hypertension undergoing noncardiac surgery should be continued on pulmonary vascular targeted therapies, such as phosphodiesterase-5 inhibitors.

Primary Hypertension

In patients with hypertension, urgent blood pressure lowering is not mandatory preoperatively unless there is evidence of

Cardiovascular Risk Management

Coronary Artery Disease

Patients with coronary artery disease (CAD) should not undergo routine coronary angiography or revascularization exclusively to reduce perioperative events. These procedures should be reserved for patients with recognized indications based on existing clinical practice guidelines. In patients who meet the criteria for intervention and in whom noncardiac surgery is time sensitive, balloon angioplasty or bare metal stent implantation should be considered over use of a drug-eluting stent. Elective noncardiac surgery should be delayed 14 days after balloon angioplasty, 30 days after bare metal stent implantation, and optimally 6 to 12 months after drug-eluting stent placement. However, if the risk of surgical delay outweighs the risk for ischemia and stent thrombosis, surgery may be considered 90 days after drug-eluting stent placement.

Patients taking β-blockers, statins, and many antihypertensive medications should continue these medications throughout the perioperative period, unless prohibited by hypotension. In hypotensive patients, dosage reduction is preferred to β-blocker discontinuation. There are also circumstances in which β-blocker or statin therapy should be initiated preoperatively (see Table 91). Postoperative β-blocker administration should be guided by clinical circumstances.

The ACC/AHA perioperative evaluation and management guideline does not recommend routinely obtaining

H end-organ dysfunction, in which case surgery should be delayed and blood pressure treated. Deferral of surgery may also be considered in patients with a systolic blood pressure of 180 mm Hg or higher or diastolic blood pressure of 110 mm Hg or higher. Moderate preoperative hypertension has not been linked to adverse perioperative outcomes, although evidence is lacking regarding a specific blood pressure threshold. The perioperative use of specific antihypertensive agents is outlined in Table 91. **H**

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KEY POINTS

- HVC** • Patients with low cardiovascular risk (<1% risk for perioperative major adverse cardiac event [MACE]) may proceed to surgery without preoperative cardiac stress testing, whereas patients with elevated risk (≥1% risk for perioperative MACE) should undergo assessment of functional capacity to determine necessity for cardiac stress testing.
- HVC** • Routine electrocardiography is not indicated in asymptomatic patients undergoing low-risk surgical procedures.
- HVC** • In patients with coronary artery disease, routine coronary angiography or revascularization should be performed for recognized indications based on existing clinical practice guidelines and should not be performed exclusively to reduce perioperative cardiovascular events.
- Patients with hypertension who are undergoing surgery do not require urgent blood pressure lowering preoperatively unless there is evidence of end-organ dysfunction.

H Pulmonary Perioperative Management

Perioperative pulmonary complications include pneumonia, respiratory failure, and exacerbation of underlying lung disease. Pulmonary perioperative management involves pulmonary risk assessment, including screening for obstructive sleep apnea (OSA), assessment of any underlying lung disease with optimization of treatment, and optimization of perioperative risk-reduction strategies.

Pulmonary Risk Assessment

Pulmonary risk factors can be categorized as patient-related risk factors or procedure-related risk factors (Table 93). Obesity and well-controlled asthma have not been shown to be independently associated with perioperative pulmonary complications. Risk calculators that include many of the important risk factors as well as other predictors, such as low oxygen saturation and the presence of preoperative sepsis, are available to help determine postoperative risk for respiratory failure, pneumonia, and overall pulmonary complications. The Postoperative Respiratory Failure Risk Calculator is available at www.surgicalriskcalculator.com/prf-risk-calculator, and the Postoperative Pneumonia Risk Calculator is available at www.surgicalriskcalculator.com/postoperative-pneumonia-risk-calculator. These calculators do not consider important

TABLE 93. Pulmonary Risk Factors

Patient-Specific Risk Factors
Age
COPD
Cigarette use
ASA class ≥2*
Functional dependence
Obstructive sleep apnea
Heart failure
Poor nutritional status
Procedure-Specific Risk Factors
Surgery in close proximity to the diaphragm (aortic, thoracic, abdominal)
Head and neck surgery
Neurosurgery
Major vascular surgery
Procedure duration >3-4 hours
Emergency surgery
ASA = American Society of Anesthesiologists.
*ASA classes are as follows: class 1, normal healthy patient; class 2, patient with mild systemic disease; class 3, patient with severe systemic disease; class 4, patient with systemic disease that is a constant threat to life; and class 5, moribund patient who is not expected to survive for 24 hours with or without operation.
Adapted with permission from Smetana GW, Lawrence VA, Cornell JE; American College of Physicians. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. <i>Ann Intern Med.</i> 2006;144:584, 587. [PMID: 16618956] Copyright 2006, American College of Physicians.

pulmonary comorbid conditions, such as COPD and OSA, but they are useful in planning for surgery and establishing informed consent.

Spirometry is not useful for predicting risk and should not be routinely ordered for preoperative evaluation, including in patients with COPD. Furthermore, evidence does not support a spirometric threshold below which the risk of surgery is unacceptable. Spirometry is indicated in patients undergoing lung resection, however, to help predict postoperative lung function. Chest radiography is not required in most patients but is indicated in patients with signs or symptoms of pulmonary disease and in patients with underlying cardiac or pulmonary disease and new or unstable symptoms.

All patients should be screened for OSA, which is associated with adverse perioperative outcomes, including cardiac events, pulmonary complications, and ICU admissions. A commonly used screening tool for OSA is the STOP-BANG score (Table 94). In high-risk patients undergoing elective surgery, the American Society of Anesthesiologists recommends further evaluation with polysomnography.

Assessment of Underlying Lung Disease

COPD is the most commonly identified risk factor for postoperative pulmonary complications. Patients should be