

may help to prevent POI. When POI is prolonged (lasting longer than 3–5 days), mechanical bowel obstruction should be considered.

Postoperative nausea and vomiting is a common event that results in significant patient distress. Risk factors include use of general anesthesia, opioids, female sex, and younger age. The internist plays an important role in ensuring adequate postoperative hydration, minimizing the use of opioids, and providing pharmacologic antiemetic therapy.

The occurrence of new postoperative atrial fibrillation, even if transient, is associated with increased short- and long-term mortality and incidence of stroke. When self-limited postoperative atrial fibrillation occurs, postoperative follow-up is indicated, including echocardiography and consideration of anticoagulation in at-risk patients.

**KEY POINTS**

- HVC • Preoperative routine laboratory panels are not recommended and can lead to unnecessary additional testing.
- In general, most medications are tolerated throughout the perioperative period.

(Continued)

**KEY POINTS (continued)**

- Early removal of indwelling catheters and voiding trials are recommended postoperatively, with ongoing close monitoring of urine output.
- Treatment of postoperative ileus includes minimization of postoperative opioids, adequate hydration, bowel rest, electrolyte repletion, and postoperative ambulation.

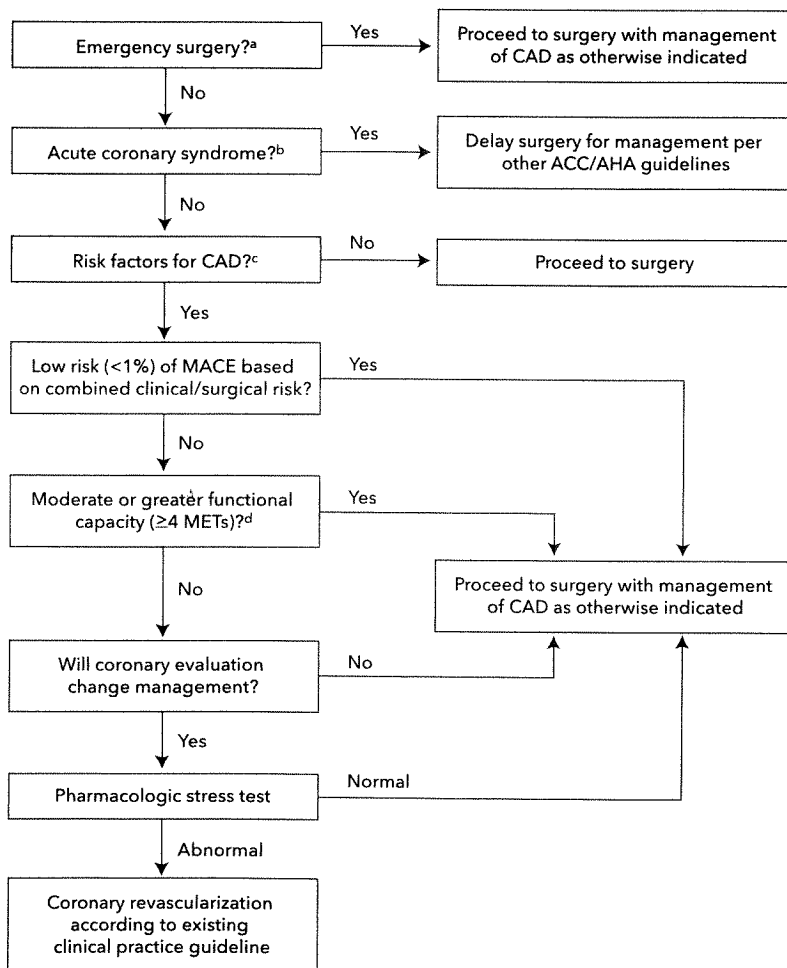
HVC

## Cardiovascular Perioperative Management

### Cardiovascular Risk Assessment

The preoperative cardiac evaluation is intended to assess patient risks for a major adverse cardiac event (MACE), such as ischemia, cardiac arrest, heart failure, and dysrhythmias, both during and after surgery. The widely accepted approach to risk stratification recommended by the American College of Cardiology (ACC)/American Heart Association (AHA) for patients undergoing noncardiac surgery is shown in **Figure 2**.

Risk calculators can be used to determine the risk for perioperative MACE. The Revised Cardiac Risk Index (RCRI)



**FIGURE 2.** 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; MET = metabolic equivalent.

<sup>a</sup>Emergency surgery required within 6 hours to avoid loss of life or limb.

<sup>b</sup>Acute coronary syndromes: myocardial infarction <30 days ago, unstable or severe angina.

<sup>c</sup>Risk 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.

<sup>d</sup>Best determined using an objective tool, such as the Duke Activity Status Index score, because subjective estimation is unreliable.

Recommendations from Fleisher LA, Fleischmann KE, Auerbach AD, 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 23. 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 <sup>a</sup> [176.8 μmol/L]) <sup>a</sup>	
Number of Points	Risk for Major Cardiac Complications <sup>b</sup>
0	0.4%-0.5%
1	1.0%-2.6%
2	2.4%-7.2%
≥3	5.4%-14.4%

<sup>a</sup>Estimated glomerular filtration rate <30 mL/min/1.73 m<sup>2</sup> is also shown to predict cardiovascular risk.

<sup>b</sup>Defined as cardiac death, nonfatal myocardial infarction, and nonfatal cardiac arrest (original validation also included pulmonary edema and complete heart block). Percentages represent incidence measured during inpatient timeframe. Validations using 30-day time frames have demonstrated significantly higher rates, even among patients with a score of 0.

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;100:1043-9. [PMID: 10477528] doi:10.1161/01.cir.100.10.1043 and Davis C, Tait G, Carroll J, et al. The Revised Cardiac Risk Index in the new millennium: a single-centre prospective cohort re-evaluation of the original variables in 9,519 consecutive elective surgical patients. *Can J Anaesth*. 2013;60:855-63. [PMID: 23813289] doi:10.1007/s12630-013-9988-5

(Table 23), the American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator (<https://riskcalculator.facs.org/RiskCalculator>), and the Gupta Perioperative Risk for Myocardial Infarction or Cardiac Arrest (MICA) Calculator ([www.surgicalriskcalculator.com/miorcardiacarrest](http://www.surgicalriskcalculator.com/miorcardiacarrest)) incorporate patient- and surgery-specific risk factors. Each calculator varies in terms of the population used for validation and overall performance (Table 24).

Patients with low calculated cardiovascular risk (<1% risk for perioperative MACE) may proceed to surgery, whereas patients with elevated risk (≥1% risk for perioperative MACE) should have functional capacity assessed. Metabolic equivalents (METs) are used to represent a patient's functional capacity based on the intensity of activity the patient is able to perform. According to the ACC/AHA guideline, if functional capacity exceeds 4 METs, the patient may proceed to surgery without further testing. The Duke Activity Status Index (DASI) score (Table 25) is a standardized and accurate means of estimating exercise capacity; data from the METS trial showed that clinician estimates of exercise capacity without use of a standardized tool do not correlate with actual patient performance on cardiopulmonary exercise testing nor with postoperative cardiac outcomes. Preoperative cardiac stress testing should be considered in patients at elevated risk for MACE with functional capacity objectively assessed to not be low risk, but only if the results will change perioperative management. An alternative approach from the Canadian Cardiovascular Society does not use preoperative cardiac stress testing and instead suggests assessing perioperative risk using patient age, presence of known cardiovascular disease, the RCRI, and B-type natriuretic peptide.

Preoperative ECG is reasonable in patients with known cardiovascular disease undergoing moderate- to high-risk surgeries. Preoperative ECG may be considered for asymptomatic patients except those undergoing low-risk procedures. ECG rarely alters preoperative decision making but may provide a useful baseline to guide postoperative management in the event of complications.

Echocardiography should not be routinely performed preoperatively. Specific indications for echocardiography include the presence of dyspnea of unknown origin, heart failure with worsening dyspnea or 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

**TABLE 24. Comparison of Tools for Estimating Major Adverse Cardiovascular Event Risk**

Characteristic	RCRI	ASC NSQIP Calculators	
		MICA Risk	Surgical Risk
External validation	Multiple studies	Minimal	Minimal
Surgical population	Inpatient (hospitalization for 2 d) for most validations	All, except for some low-risk procedures	All, except for some low-risk procedures
Measured cardiovascular outcomes	MI, cardiac death/ventricular fibrillation, pulmonary edema, complete heart block	MICA	MI and cardiac death
Outcome measurement time frame	Inpatient only for most validations	30 d postoperatively	30 d postoperatively
Limitations	Tendency to overestimate risk	Surgical types combined into broad categories that could lead to inaccurate assessment of risk	Tendency to overestimate risk

ACS NSQIP = American Cancer Society National Surgical Quality Improvement Program; MI = myocardial infarction; MICA = myocardial infarction and cardiac arrest; RCRI = Revised Cardiac Risk Index.

**TABLE 25. Duke Activity Status Index (DASI) Score Questionnaire**

Questionnaire Item	Points (each "Yes" answer) <sup>a</sup>
1. Can you take care of yourself (e.g., eat, dress, bathe, or use the toilet)?	2.75
2. Can you walk indoors (e.g., throughout the rooms of your house)?	1.75
3. Can you walk one to two blocks on level ground?	2.75
4. Can you climb a flight of stairs or walk up a hill?	5.50
5. Can you run a short distance?	8.00
6. Can you do <i>light</i> work around the house (e.g., dusting, washing dishes)?	2.70
7. Can you do <i>moderate</i> work around the house (e.g., vacuuming, sweeping floors, or carrying groceries)?	3.50
8. Can you do <i>heavy</i> work around the house (e.g., scrubbing floors, lifting or moving heavy furniture)?	8.00
9. Can you do yard work (e.g., raking leaves, weeding, pushing a power lawnmower)?	4.50
10. Can you have sexual relations?	5.25
11. Can you participate in <i>moderate</i> recreational activities (e.g., golf, bowling, dancing, doubles tennis, or throwing a ball)?	6.00
12. Can you participate in <i>strenuous</i> sports (e.g., swimming, singles tennis, football, basketball, or skiing)?	7.50

<sup>a</sup>In Wijeyesundera and colleagues 2020, a DASI score of 34 (equivalent to ~5 METs in the study population) was the cutoff below which patients experienced elevated risk for 30-day mortality and myocardial infarction.

Reproduced with permission from Hlatky MA, Boineau RE, Higginbotham MB, et al. A brief self-administered questionnaire to determine functional capacity (the Duke Activity Status Index). *Am J Cardiol.* 1989;64:651-4. [PMID: 2782256] doi:10.1016/0002-9149(89)90496-7

Wijeyesundera DN, Beattie WS, Hillis GS, et al; Measurement of Exercise Tolerance before Surgery Study investigators. Integration of the Duke Activity Status Index into preoperative risk evaluation: a multicentre prospective cohort study. *Br J Anaesth.* 2020;124:261-70. [PMID: 31864719] doi:10.1016/j.bja.2019.11.025

echocardiographic assessment in the past year or with a change in clinical status.

## Cardiovascular Risk Management

### Coronary Artery Disease

Patients with coronary artery disease should not undergo routine coronary angiography or revascularization before surgery. These procedures should be reserved for patients with recognized indications based on clinical practice guidelines. It is recommended that elective surgery be delayed 14 days after balloon angioplasty, 30 days after bare metal stent implantation, and 6 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 placement. Patients with an acute coronary syndrome not managed with coronary intervention are still at elevated risk for postoperative MACE, and elective surgery should be delayed for at least 60 days after the event.

Patients taking  $\beta$ -blockers, statins, and most antihypertensive medications (with the possible exceptions of diuretics and ACE inhibitors) should continue these medications perioperatively unless prohibited by hypotension. In some circumstances,  $\beta$ -blocker or statin therapy is initiated preoperatively (see Table 22). Postoperative  $\beta$ -blocker administration should be guided by clinical circumstances, but dose reduction is preferred to discontinuation if hypotension develops.

The ACC/AHA perioperative evaluation and management guideline does not recommend routine measurement of postoperative troponin or ECG, but these studies should be obtained if signs or symptoms of myocardial ischemia develop. However, in many cases, postoperative myocardial ischemia is asymptomatic or presents atypically. The Canadian Cardiovascular Society recommends daily measurement of troponin levels for up to 3 days after surgery in patients at elevated risk for MACE, although the best means of managing patients with postoperative low-level troponin elevations is unclear.

### Heart Failure

Medical management of decompensated heart failure should be optimized before surgery (see MKSAP 19 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 euvoemia, optimizing pain management, and continuing baseline rate control medications can reduce this risk.

A cardiologist should be consulted in patients with a pacemaker or implantable cardioverter-defibrillator who are undergoing surgery to assure normal device function and obtain recommendations for perioperative management of the device. 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 elective noncardiac surgery in patients with severe asymptomatic aortic stenosis, mitral regurgitation, or aortic regurgitation with preserved left ventricular function. However, these patients are at higher risk for cardiovascular complications, necessitating awareness among surgical teams. Efforts to avoid large volume shifts and minimizing hypotension and

tachycardia are critical. Valvular intervention should be performed before elective noncardiac surgery in patients who are candidates for valvular intervention owing to symptoms or severity of disease.

**Pulmonary Hypertension**

Patients with pulmonary hypertension undergoing noncardiac surgery have higher mortality and morbidity, including nonfatal myocardial ischemia, VTE, cardiogenic shock, and dysrhythmias. Preoperative evaluation by a pulmonary hypertension specialist is advised for patients with high-risk features, including group 1 pulmonary hypertension (pulmonary arterial hypertension), pulmonary artery 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. Postoperatively, maintaining preload, optimal pain control, and normal heart rate and blood pressure are important. Patients should be continued on pulmonary vascular targeted therapies, such as phosphodiesterase-5 inhibitors and prostacyclin analogues.

**Hypertension**

In patients with hypertension, urgent blood pressure lowering is not mandatory preoperatively unless there is evidence of 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 22.

**KEY POINTS**

- HVC** • Patients with low cardiovascular risk (<1% risk for perioperative major adverse cardiac event [MACE]) may proceed to surgery, whereas patients with elevated risk (≥1% risk for perioperative MACEs) should undergo objective assessment of functional capacity.
- HVC** • Preoperative ECG is reasonable in patients with known cardiovascular disease undergoing moderate- to high-risk surgeries and may be considered for other asymptomatic patients, except those undergoing low-risk procedures.
- HVC** • Patients with coronary artery disease should not undergo routine coronary angiography or revascularization before surgery exclusively to reduce perioperative events.
- Patients with hypertension who are undergoing surgery do not require urgent blood pressure lowering preoperatively unless there is evidence of end-organ dysfunction.

**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 underlying lung disease and treatment optimization, and use of perioperative risk-reduction strategies.

**Pulmonary Risk Assessment**

Patients should be asked preoperatively about any recent signs or symptoms of acute respiratory illness or chronic lung disease exacerbation.

Pulmonary risk factors can be categorized as patient-related factors or procedure-related factors (Table 26). Risk calculators that include many of the important risk factors and other predictors may help determine postoperative risk for respiratory failure, pneumonia, and overall pulmonary complications. The ARISCAT score has been externally validated and measures risk for a wide variety of perioperative pulmonary complications (www.mdcalc.com/ariscat-score-postoperative-pulmonary-complications). To date, ARISCAT

TABLE 26. Pulmonary Risk Factors	
<b>Patient-Related Risk Factors</b>	
Age	
COPD	
Cigarette use	
ASA class ≥2 <sup>a</sup>	
Functional dependence	
Obstructive sleep apnea	
Heart failure	
Serum albumin level <3 g/dL (30 g/L)	
<b>Procedure-Related Risk Factors</b>	
Surgery in close proximity to the airway or diaphragm (aortic, thoracic, abdominal)	
Head and neck surgery	
Neurosurgery	
Major vascular surgery	
Procedure duration >2 h	
Emergency surgery	
<p>ASA = American Society of Anesthesiologists.</p> <p><sup>a</sup>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.</p> <p>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] doi: 10.7326/0003-4819-144-8-200604180-00009</p> <p>Copyright 2006, American College of Physicians.</p>	