Complete Summary

GUIDELINE TITLE

ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery.

BIBLIOGRAPHIC SOURCE(S)

Fleisher LA, Beckman JA, Brown KA, Calkins H, Chaikof E, Fleischmann KE, Freeman WK, Froehlich JB, Kasper EK, Kersten JR, Riegel B, Robb JF, Smith SC Jr, Jacobs AK, Adams CD, Anderson JL, Antman EM, Buller CE, Creager MA, Ettinger SM, Faxon DP, Fuster V, Halperin JL, Hiratzka LF, Hunt SA, Lytle BW, Nishimura R, Ornato JP, Page RL, Riegel B, Tarkington LG, Yancy CW, American College of Cardiology, American Heart Association Task Force on Practice Guidelines (writing Committee, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society for Vascular Surgery. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery. J Am Coll Cardiol 2007 Oct 23;50(17):e159-241. [584 references] PubMed

GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: American College of Cardiology Foundation (ACCF), American Heart Association (AHA). ACC/AHA guideline update on perioperative cardiovascular evaluation for noncardiac surgery. A report of the American College of Cardiology/American Heart Association Task Force on practice guidelines (Committee to Update the 1996 Guidelines). Bethesda (MD): American College of Cardiology Foundation; 2002. 58 p. [390 references]

Fleisher LA, Beckman JA, Freeman WK, Brown KA, Froeclich JB, Calkins H, Kasper EK, Chaikof E, Kersten JR, Fleischmann KE, Riegel B. ACC/AHA 2006 guideline update on perioperative cardiovascular evaluation on noncardiac surgery: focused update on perioperative beta-blocker therapy. A report of the American College of Cardiology/American Heart Association Task Force on Practice [trunc]. J Am Coll Cardiol 2006;47:1-12. [25 references]

**** REGULATORY ALERT ****

FDA WARNING/REGULATORY ALERT

Note from the National Guideline Clearinghouse: This guideline references a drug(s)/intervention(s) for which important revised regulatory and/or warning information has been released.

- August 16, 2007, Coumadin (Warfarin): Updates to the labeling for Coumadin to include pharmacogenomics information to explain that people's genetic makeup may influence how they respond to the drug.
- June 8, 2007, Troponin-I Immunoassay: Class I Recall of all lots of the Architect Stat Troponin-I Immunoassay. The assay may report falsely elevated or falsely decreased results at and near a low level, which may impact patient treatment.

COMPLETE SUMMARY CONTENT

** REGULATORY ALERT **
SCOPE
METHODOLOGY - including Rating Scheme and Cost Analysis
RECOMMENDATIONS
EVIDENCE SUPPORTING THE RECOMMENDATIONS
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INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES
IDENTIFYING INFORMATION AND AVAILABILITY
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SCOPE

DISEASE/CONDITION(S)

- Cardiovascular diseases, including:
  - Coronary artery disease
  - Myocardial infarction
  - Angina pectoris
  - Heart failure
  - Arrhythmias (high-grade, Mobitz II, or third-degree atrioventricular block; symptomatic ventricular arrhythmia; supraventricular arrhythmias (including atrial fibrillation), symptomatic bradycardia, newly recognized tachycardia, orthostatic intolerance)
  - Conduction defects
  - Hypertension
  - Cardiomyopathy
  - Valvular heart disease (severe aortic stenosis, symptomatic mitral stenosis)
  - Pulmonary vascular disease
  - Controlled arrhythmias (presence of implanted pacemakers and implantable cardioverter defibrillators)

GUIDELINE CATEGORY

Evaluation
Management
Risk Assessment

CLINICAL SPECIALTY

Anesthesiology
Cardiology
Emergency Medicine
Family Practice
Internal Medicine
Nuclear Medicine
Surgery

INTENDED USERS

Physicians

GUIDELINE OBJECTIVE(S)

- To provide a framework for considering cardiac risk of noncardiac surgery in a variety of patient and surgical situations
- To guide preoperative evaluation to determine the patient's current medical status
- To make recommendations concerning the evaluation, management, and risk of cardiac problems over the entire perioperative period
- To provide a clinical risk profile that the patient, primary physician, nonphysician caregivers, anesthesiologist, and surgeon can use in making treatment decisions that may influence short- and long-term cardiac outcomes
- To update the 2002 recommendations on perioperative cardiovascular evaluation and care for noncardiac surgery

TARGET POPULATION

Patients undergoing noncardiac surgery

INTERVENTIONS AND PRACTICES CONSIDERED

Risk Assessment

1. Clinical history
2. Physical examination
3. Assessment of comorbid disease (pulmonary disease, diabetes mellitus, renal impairment, hematologic disorders)
4. Ancillary studies, as needed (e.g., laboratory evaluation, chest x-ray, standard electrocardiogram [ECG])
5. Stepwise approach to perioperative cardiac assessment (clinical risk factors, prior coronary history and treatment, functional capacity, and surgery-specific risk)
6. Supplemental preoperative evaluation:
    - Resting left ventricular function
    - 12-lead ECG
    - Exercise or pharmacological stress testing
    - Myocardial perfusion imaging

- Dobutamine stress echocardiography
- Ambulatory ECG monitoring
- Coronary angiography

Management

1. Perioperative therapy
    - Surgical coronary revascularization: preoperative coronary artery bypass grafting (CABG); percutaneous coronary intervention with or without stents (either bare metal or drug-eluting, with or without post-stent pharmacologic therapy [aspirin, clopidogrel]); percutaneous transluminal coronary angioplasty (PTCA)
    - Pharmacologic management: beta-blocker, alpha-2 agonist, and statin therapy; calcium channel blockers (no recommendation)
2. Management of specific cardiovascular conditions
3. Anesthetic considerations and intraoperative management
    - Anesthetic technique and agent
    - Perioperative pain management
    - Intraoperative nitroglycerin
    - Transesophageal echocardiography
    - Maintenance of body temperature
    - Intra-aortic balloon counterpulsation devices
    - Control of blood glucose concentration
4. Perioperative surveillance
    - Pulmonary artery catheters
    - ST-segment monitoring
    - Surveillance for perioperative myocardial infarction (MI)
    - Management of postoperative arrhythmias and conduction disorders
5. Postoperative and long-term management
    - Surveillance and treatment of MI
    - Cardiovascular medical therapy

MAJOR OUTCOMES CONSIDERED

- Positive and negative predictive value of tests for myocardial infarction or death
- Short- and long term cardiac outcomes, such as perioperative cardiovascular morbidity (e.g., myocardial infarction, unstable angina, congestive heart failure, ventricular tachycardia, stroke) and mortality (e.g., cardiac death)
- Economic outcomes (e.g., length of hospitalization, hospital resource use [intensive care])

METHODOLOGY

METHODS USED TO COLLECT/SELECT EVIDENCE

Hand-searches of Published Literature (Primary Sources)
Hand-searches of Published Literature (Secondary Sources)
Searches of Electronic Databases

DESCRIPTION OF METHODS USED TO COLLECT/SELECT THE EVIDENCE

The American College of Cardiology/American Heart Association Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery conducted a comprehensive review of the literature relevant to perioperative cardiac evaluation since the last publication of these guidelines in 2002. Literature searches were conducted in the following databases: PubMed, MEDLINE, and the Cochrane Library (including the Cochrane Database of Systematic Reviews and the Cochrane Controlled Trials Register). Searches were limited to the English language, the years 2002 through 2007, and human subjects. Related-article searches were conducted in MEDLINE to find further relevant articles. Finally, committee members recommended applicable articles outside the scope of the formal searches.

Major search topics included perioperative risk, cardiac risk, noncardiac surgery, intraoperative risk, postoperative risk, risk stratification, cardiac complication, cardiac evaluation, perioperative care, preoperative evaluation, preoperative assessment, and intraoperative complications. Additional searches cross-referenced these topics with the following subtopics: troponin, myocardial infarction (MI), myocardial ischemia, Duke activity status index, functional capacity, dobutamine, adenosine, venous thrombosis, thromboembolism, warfarin, percutaneous transluminal coronary angioplasty (PTCA), stent, adrenergic beta agonists, echocardiography, anticoagulant, beta blocker, coronary artery bypass surgery, valve, diabetes mellitus, wound infection, blood sugar control, normothermia, body temperature changes, body temperature regulation, hypertension, pulmonary hypertension, anemia, aspirin, arrhythmia, implantable defibrillator, artificial pacemaker, pulmonary artery catheters, Swan-Ganz catheter, and platelet aggregation inhibitors.

As a result of these searches, more than 400 relevant, new articles were identified and reviewed by the committee for the revision of these guidelines.

NUMBER OF SOURCE DOCUMENTS

Not stated

METHODS USED TO ASSESS THE QUALITY AND STRENGTH OF THE EVIDENCE

Weighting According to a Rating Scheme (Scheme Given)

RATING SCHEME FOR THE STRENGTH OF THE EVIDENCE

Applying Classification of Recommendations and Level of Evidence

	SIZE OF TREATMENT EF

		CLASS I *Benefit >>> Risk* Procedure/Treatment **SHOULD** be performed/ administered	CLASS IIa *Benefit >> Risk* *Additional studies with focused objectives needed* **IT IS REASONABLE** to perform procedure/ administer treatment	CLASS I *Benefit >* *Additiona* *objective* *registry* *helpful* Procedur **BE CONS**
Estimate of Certainty (Precision) of Treatment Effect	**LEVEL A** Multiple (3–5) population risk strata evaluated* General consistency of direction and magnitude of effect	• Recommendation that procedure or treatment is useful/effective • Sufficient evidence from multiple randomized trials or meta-analyses	• Recommendation in favor of treatment of procedure being useful/effective • Some conflicting evidence from multiple randomized trials or meta-analyses	• R us le • G ev m tr ar
	LEVEL B Limited (2–3) population risk strata evaluated*	• Recommendation that procedure or treatment is useful/effective • Limited evidence from single randomized trial or nonrandomized studies	• Recommendation in favor of treatment of procedure being useful/effective • Some conflicting evidence from single randomized trial or nonrandomized studies	• R us le • G ev ra no st
	LEVEL C Very limited (1–2) population risk strata evaluated*	• Recommendation that procedure or treatment is useful/effective • Only expert opinion, case studies, or standard-of-care	• Recommendation in favor of treatment of procedure being useful/effective • Only diverging expert opinion, case studies, or standard-of-care	• R us le • O op or

*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as gender, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use. A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Even though randomized trials are not available, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

NOTE: In 2003, the American College of Cardiology/American Heart Association (ACC/AHA) Task Force on Practice Guidelines developed a list of suggested phrases to use when writing recommendations. All guideline recommendations have been written in full sentences that express a complete thought, such that a recommendation, even if separated and presented apart from the rest of the document (including headings above sets of recommendations), would still convey the full intent of the recommendation. It is hoped that this will increase readers' comprehension of the guidelines and will allow queries at the individual recommendation level. (See Table 1 in the original guideline document for a list of suggested phrases for writing recommendations.)

METHODS USED TO ANALYZE THE EVIDENCE

Review of Published Meta-Analyses
Systematic Review with Evidence Tables

DESCRIPTION OF THE METHODS USED TO ANALYZE THE EVIDENCE

Not stated

METHODS USED TO FORMULATE THE RECOMMENDATIONS

Expert Consensus

DESCRIPTION OF METHODS USED TO FORMULATE THE RECOMMENDATIONS

Experts in the subject under consideration have been selected from the American College of Cardiology (ACC) Foundation and the American Heart Association (AHA) to examine subject-specific data and write guidelines. The process includes additional representatives from other medical practitioner and specialty groups when appropriate. Writing groups are specifically charged to perform a formal literature review, weigh the strength of evidence for or against a particular treatment or procedure, and include estimates of expected health outcomes where data exist. Patient-specific modifiers, comorbidities, and issues of patient preference that may influence the choice of particular tests or therapies are considered, as well as frequency of follow-up and cost-effectiveness.

RATING SCHEME FOR THE STRENGTH OF THE RECOMMENDATIONS

See the "Rating Scheme for the Strength of the Evidence" field above.

COST ANALYSIS

Implications of Guidelines and Other Risk Assessment Strategies for Costs and Outcomes

The decision to recommend further testing or treatment for the individual patient being considered for noncardiac surgery ultimately becomes a balancing act between the estimated probabilities of effectiveness versus risk. The proposed benefit, of course, is the possibility of identifying and/or treating advanced but relatively unsuspected coronary artery disease (CAD) that might result in significant cardiac morbidity or mortality either perioperatively or in the long term. In the process of further screening and treatment, the risks from the tests and treatments themselves may offset or even exceed the potential benefit of evaluation. Furthermore, the cost of screening and treatment strategies must be considered. Although physicians should be concerned with improving the clinical outcome of their patients, cost is an appropriate consideration when different evaluation and treatment strategies are available that cannot be distinguished from one another in terms of clinical outcome.

One study compared test utilization and outcome for aortic surgery patients before and after implementation of the American College of Cardiology (ACC) Foundation/American Heart Association (AHA) preoperative assessment guidelines at the authors' center using a comprehensive educational program. They demonstrated dramatic reductions in stress testing after implementation of the guidelines, mostly with nuclear imaging (88% to 47%), cardiac catheterization (24% to 11%), coronary revascularization (24% to 2%), and overall preoperative costs ($1087 to $171). At the same time, perioperative outcome was actually improved as the death/myocardial infarction (MI) rate fell from 11% to 4%. Of note, implementation of the guidelines had the greatest impact in the preoperative evaluation of clinically low-risk patients. This study supports the ACC/AHA guideline approach of clinical assessment of risk followed by selective testing with stress nuclear myocardial perfusion imaging in higher-risk subgroups of patients, and they confirm that cardiac patients at low clinical risk can typically undergo elective surgery with a low event rate without further testing. The approach of selective testing, based on an understanding of test performance, a clinical patient assessment, and the potential impact of test results on clinical decision making, is supported as leading to appropriateness of testing, as outlined in the ACC Foundation/American Society of Nuclear Cardiology proposed method for evaluating the appropriateness of cardiovascular imaging.

Formal decision and cost-effectiveness analyses of the value of preoperative cardiac evaluation models were created before the publication of the CARP (Coronary Artery Revascularization Prophylaxis) trial and the DECREASE (Dutch Echocardiographic Cardiac Risk Evaluation Applying Stress Echocardiography)-II trial and assumed that coronary revascularization had benefits in clinical populations that differed from center to center; therefore, it is difficult to determine the exact risks of aggressive screening and treatments versus the benefits in terms of risk reduction. Additionally, the models all demonstrate that optimal strategy depends on the mortality rates for both cardiac procedures and noncardiac surgeries in the clinically relevant range. One model, which did not support a strategy incorporating coronary angiography and revascularization, used lower mortality rates than those used or reported in the other studies. Therefore, use of any decision and cost-effectiveness model in a specific situation depends on the comparability of local mortality rates to those of the model.

One report suggested that the cost of a selected coronary screening approach, as described in the present guidelines, was as low as $214 per patient. Resource

utilization and costs of preoperative evaluation also decreased in patients undergoing elective abdominal aortic surgery in the period of implementation for the initial version of these guidelines compared with historical controls, whereas outcomes were similar. Several publications have shown a cost per year of life saved for this selected screening strategy of less than $45,000 when applied to patients undergoing vascular surgery. However, none of these studies included a strategy of selected screening followed by aggressive beta-blocker treatment in high-risk individuals, as recently described by Poldermans and colleagues.

Available data suggest that implementation of various strategies of beta blockade in patients undergoing major vascular surgery is cost-effective and even cost-saving from the perspective of a short-term provider. One study used decision analytic techniques to compare 5 different strategies for implementing beta blockade in patients undergoing abdominal aortic aneurysm surgery. These ranged from 1) no routine beta blockade to 2) oral bisoprolol 7 days preoperatively followed by perioperative intravenous metoprolol and oral bisoprolol, 3) immediate preoperative atenolol with postoperative intravenous then oral atenolol, 4) intraoperative esmolol with conversion to intravenous and then oral atenolol in the immediate postoperative period, and 5) intra operative and postoperative (at 18 hours) esmolol followed by atenolol. Using Medicare costs as a proxy, the authors found that the institution of an oral beta blocker a minimum of 7 days before surgery was associated with a cost savings of approximately $500 from the hospital's perspective; that is, beta blockade was associated with both better outcomes and lower cost. All other strategies tested were cost saving, but to a lesser degree. Of note, this decision analysis did not include the performance of any screening tests or the costs of such testing. Another study estimated the impact of a clinical practice guideline for perioperative beta blockers at a medical center in western Massachusetts in high-risk patients with 2 or more cardiac risk factors or known CAD. Using effectiveness data for beta-blocker treatment from another study, the authors estimated that full use of beta blockers in eligible patients could result in 62 to 89 fewer deaths annually at a cost of approximately $33 000 to $40 000. Prophylactic beta blockade also represents an excellent strategy in patients for whom coronary revascularization for long-term benefit is not a serious consideration.

METHOD OF GUIDELINE VALIDATION

External Peer Review
Internal Peer Review

DESCRIPTION OF METHOD OF GUIDELINE VALIDATION

This document was approved by the American College of Cardiology Foundation (ACCF) Board of Trustees in June 2007 and by the American Heart Association (AHA) Science Advisory and Coordinating Committee in June 2007.

A list of all peer reviewers (official, organizational, and content) is provided in "Conflicts of Interest/Financial Disclosures" below and in Appendix II of the original guideline document.

RECOMMENDATIONS

MAJOR RECOMMENDATIONS

The American College of Cardiology/American Heart Association (ACC/AHA) classification of the recommendations for patient evaluation and treatment (classes I-III) and the levels of evidence (A-C) are defined at the end of the Major Recommendations field.

General Approach to the Patient

Table: Active Cardiac Conditions for Which the Patient Should Undergo Evaluation and Treatment Before Noncardiac Surgery (Class I, Level of Evidence: B)

Condition	Examples
Unstable coronary syndromes	Unstable or severe angina* (Canadian Cardiovascular Society [CCS] class III or IV)** Recent myocardial infarction (MI)***
Decompensated heart failure (HF) (New York Heart Association [NYHA] functional class IV; worsening or new-onset HF)	
Significant arrhythmias	High-grade atrioventricular block Mobitz II atrioventricular block Third-degree atrioventricular heart block Symptomatic ventricular arrhythmias Supraventricular arrhythmias (including atrial fibrillation) with uncontrolled ventricular rate (heart rate [HR] greater than 100 beats per minute at rest) Symptomatic bradycardia Newly recognized ventricular tachycardia
Severe valvular disease	Severe aortic stenosis (mean pressure gradient greater than 40 mm Hg, aortic valve area less than 1.0 cm^2, or symptomatic)

	Symptomatic mitral stenosis (progressive dyspnea on exertion, exertional presyncope, or HF)

*According to Campeau (Campeau L. Letter: grading of angina pectoris. Circulation 1976;54:522-3).

**May include "stable" angina in patients who are unusually sedentary.

***The American College of Cardiology National Database Library defines recent MI as more than 7 days but less than or equal to 1 month (within 30 days).

Supplemental Preoperative Evaluation

Assessment of Left Ventricular (LV) Function

Recommendations for Preoperative Noninvasive Evaluation of Left Ventricular Function

Class IIa

1. It is reasonable for patients with dyspnea of unknown origin to undergo preoperative evaluation of left ventricular (LV) function. (*Level of Evidence: **C***)
2. It is reasonable for patients with current or prior heart failure with worsening dyspnea or other change in clinical status to undergo preoperative evaluation of LV function if not performed within 12 months. (*Level of Evidence: **C***)

Class IIb

1. Reassessment of LV function in clinically stable patients with previously documented cardiomyopathy is not well established. (*Level of Evidence: **C***)

Class III

1. Routine perioperative evaluation of LV function in patients is not recommended. (*Level of Evidence: **B***)

Assessment of Risk for Coronary Artery Disease (CAD) and Assessment of Functional Capacity

Recommendations for Preoperative Resting 12-Lead Electrocardiogram (ECG)

Class I

1. Preoperative resting 12-lead ECG is recommended for patients with at least 1 clinical risk factor* who are undergoing vascular surgical procedures. (*Level of Evidence: **B***)

*Clinical risk factors include history of ischemic heart disease, history of compensated or prior heart failure, history of cerebrovascular disease, diabetes mellitus, and renal insufficiency.

2. Preoperative resting 12-lead ECG is recommended for patients with known coronary heart disease, peripheral arterial disease, or cerebrovascular disease who are undergoing intermediate-risk surgical procedures. (*Level of Evidence: **C***)

Class IIa

1. Preoperative resting 12-lead ECG is reasonable in persons with no clinical risk factors who are undergoing vascular surgical procedures. (*Level of Evidence: **B***)

Class IIb

1. Preoperative resting 12-lead ECG may be reasonable in patients with at least 1 clinical risk factor who are undergoing intermediate-risk operative procedures. (*Level of Evidence: **B***)

Class III

1. Preoperative and postoperative resting 12-lead ECGs are not indicated in asymptomatic persons undergoing low-risk surgical procedures. (*Level of Evidence: **B***)

Recommendations for Noninvasive Stress Testing Before Noncardiac Surgery

Class I

1. Patients with active cardiac conditions (see the Table above) in whom noncardiac surgery is planned should be evaluated and treated per American College of Cardiology/American Heart Association (ACC/AHA) guidelines (see the original guideline document for the list of guidelines) before noncardiac surgery. (*Level of Evidence: **B***)

Class IIa

1. Noninvasive stress testing of patients with 3 or more clinical risk factors and poor functional capacity (less than 4 metabolic equivalents [METs]) who require vascular surgery (i.e., aortic and other major vascular and peripheral vascular surgery) is reasonable if it will change management. (*Level of Evidence: **B***)

Class IIb

1. Noninvasive stress testing may be considered for patients with at least 1 to 2 clinical risk factors and poor functional capacity (less than 4 METs) who require intermediate-risk noncardiac surgery if it will change management. (*Level of Evidence: **B***)

2. Noninvasive stress testing may be considered for patients with at least 1 to 2 clinical risk factors and good functional capacity (greater than or equal to 4 METs) who are undergoing vascular surgery. (*Level of Evidence: **B***)

Class III

1. Noninvasive testing is not useful for patients with no clinical risk factors undergoing intermediate-risk noncardiac surgery. (*Level of Evidence: **C***)
2. Noninvasive testing is not useful for patients undergoing low-risk noncardiac surgery. (*Level of Evidence: **C***)

Perioperative Therapy

Preoperative Coronary Revascularization With Coronary Artery Bypass Grafting (CABG) or Percutaneous Coronary Intervention

(All of the Class I indications below are consistent with the ACC/AHA 2004 Guideline Update for Coronary Artery Bypass Graft Surgery.)

Class I

1. Coronary revascularization before noncardiac surgery is useful in patients with stable angina who have significant left main coronary artery stenosis. (*Level of Evidence: **A***)
2. Coronary revascularization before noncardiac surgery is useful in patients with stable angina who have 3-vessel disease. (Survival benefit is greater when left ventricular ejection fraction is less than 0.50.) (*Level of Evidence: **A***
3. Coronary revascularization before noncardiac surgery is useful in patients with stable angina who have 2-vessel disease with significant proximal left anterior descending stenosis and either ejection fraction less than 0.50 or demonstrable ischemia on noninvasive testing. (*Level of Evidence: **A***)
4. Coronary revascularization before noncardiac surgery is recommended for patients with high-risk unstable angina or non–ST-segment elevation myocardial infarction (MI).* (*Level of Evidence: **A***)

   *High-risk unstable angina/non–ST-elevation MI patients were identified as those with age greater than 75 years, accelerating tempo of ischemic symptoms in the preceding 48 hours, ongoing rest pain greater than 20 minutes in duration, pulmonary edema, angina with S_3 gallop or rales, new or worsening mitral regurgitation murmur, hypotension, bradycardia, tachycardia, dynamic ST-segment change greater than or equal to 1 mm, new or presumed new bundle-branch block on ECG, or elevated cardiac biomarkers, such as troponin.

5. Coronary revascularization before noncardiac surgery is recommended in patients with acute ST-elevation MI. (*Level of Evidence: **A***)

Class IIa

1. In patients in whom coronary revascularization with percutaneous coronary intervention (PCI) is appropriate for mitigation of cardiac symptoms and who need elective noncardiac surgery in the subsequent 12 months, a strategy of balloon angioplasty or bare-metal stent placement followed by 4 to 6 weeks of dual-antiplatelet therapy is probably indicated. (*Level of Evidence: **B***)

2. In patients who have received drug-eluting coronary stents and who must undergo urgent surgical procedures that mandate the discontinuation of thienopyridine therapy, it is reasonable to continue aspirin if at all possible and restart the thienopyridine as soon as possible. (*Level of Evidence: **C***)

Class IIb

1. The usefulness of preoperative coronary revascularization is not well established in high-risk ischemic patients (e.g., abnormal dobutamine stress echocardiogram with at least 5 segments of wall-motion abnormalities). (*Level of Evidence: **C***)
2. The usefulness of preoperative coronary revascularization is not well established for low-risk ischemic patients with an abnormal dobutamine stress echocardiogram (segments 1 to 4). (*Level of Evidence: **B***)

Class III

1. It is not recommended that routine prophylactic coronary revascularization be performed in patients with stable CAD before noncardiac surgery. (*Level of Evidence: **B***)
2. Elective noncardiac surgery is not recommended within 4 to 6 weeks of bare-metal coronary stent implantation or within 12 months of drug-eluting coronary stent implantation in patients in whom thienopyridine therapy or aspirin and thienopyridine therapy will need to be discontinued perioperatively. (*Level of Evidence: **B***)
3. Elective noncardiac surgery is not recommended within 4 weeks of coronary revascularization with balloon angioplasty. (*Level of Evidence: **B***)

Perioperative Medical Therapy

Recommendations for Beta-Blocker Medical Therapy

Care should be taken in applying recommendations on beta-blocker therapy to patients with decompensated heart failure, nonischemic cardiomyopathy, or severe valvular heart disease in the absence of coronary heart disease.

Class I

1. Beta blockers should be continued in patients undergoing surgery who are receiving beta blockers to treat angina, symptomatic arrhythmias, hypertension, or other ACC/AHA Class I guideline indications. (*Level of Evidence: **C***)
2. Beta blockers should be given to patients undergoing vascular surgery who are at high cardiac risk owing to the finding of ischemia on preoperative testing. (*Level of Evidence: **B***)

Class IIa

1. Beta blockers are probably recommended for patients undergoing vascular surgery in whom preoperative assessment identifies coronary heart disease (CHD). (*Level of Evidence: **B***)

2. Beta blockers are probably recommended for patients in whom preoperative assessment for vascular surgery identifies high cardiac risk, as defined by the presence of more than 1 clinical risk factor (defined under "Recommendations for Preoperative Resting 12-Lead ECG," above). (*Level of Evidence: **B***)
3. Beta blockers are probably recommended for patients in whom preoperative assessment identifies CHD or high cardiac risk, as defined by the presence of more than 1 clinical risk factor (defined under "Recommendations for Preoperative Resting 12-Lead ECG," above), who are undergoing intermediate-risk or vascular surgery. (*Level of Evidence: **B***)

Class IIb

1. The usefulness of beta blockers is uncertain for patients who are undergoing either intermediate-risk procedures or vascular surgery, in whom preoperative assessment identifies a single clinical risk factor (defined under "Recommendations for Preoperative Resting 12-Lead ECG," above). (*Level of Evidence: **C***)
2. The usefulness of beta blockers is uncertain in patients undergoing vascular surgery with no clinical risk factors who are not currently taking beta blockers. (*Level of Evidence: **B***)

Class III

1. Beta blockers should not be given to patients undergoing surgery who have absolute contraindications to beta blockade. (*Level of Evidence: **C***)

Table: Recommendations for Perioperative Beta-Blocker Therapy Based on Published Randomized Clinical Trials

Surgery	No Clinical Risk Factors	1 or More Clinical Risk Factors	CHD or High Cardiac Risk	Patients Currently Taking Beta Blockers
Vascular	Class IIb, Level of Evidence: **B**	Class IIa, Level of Evidence: **B**	Patients found to have myocardial ischemia on preoperative testing: Class I, Level of Evidence: **B*** Patients without ischemia or no previous test: Class IIa, Level of Evidence: **B**	Class I, Level of Evidence: **B**
Intermediate risk	...	Class IIb, Level of Evidence: **C**	Class IIa, Level of Evidence: **B**	Class I, Level of Evidence: **C**
Low risk	…	…	…	Class I, Level of Evidence: **C**

See Table 4 of the original guideline document for definition of procedures. Ellipses (…) indicate that data were insufficient to determine a class of recommendation or level of evidence. See text for further discussion. CHD indicates coronary heart disease.

*Applies to patients found to have coronary ischemia on preoperative testing

Recommendations for Statin Therapy

Class I

1. For patients currently taking statins and scheduled for noncardiac surgery, statins should be continued. (*Level of Evidence: **B***)

Class IIa

1. For patients undergoing vascular surgery with or without clinical risk factors, statin use is reasonable. (*Level of Evidence: **B***)

Class IIb

1. For patients with at least 1 clinical risk factor who are undergoing intermediate-risk procedures, statins may be considered. (*Level of Evidence: **C***)

Recommendations for Alpha-2 Agonists

Class IIb

1. Alpha-2 agonists for perioperative control of hypertension may be considered for patients with known CAD or at least 1 clinical risk factor who are undergoing surgery. (*Level of Evidence: **B***)

Class III

1. Alpha-2 agonists should not be given to patients undergoing surgery who have contraindications to this medication. (*Level of Evidence: **C***)

Preoperative Intensive Care Monitoring

Class IIb

1. Preoperative intensive care monitoring with a pulmonary artery catheter for optimization of hemodynamic status might be considered; however, it is rarely required and should be restricted to a very small number of highly selected patients whose presentation is unstable and who have multiple comorbid conditions. (*Level of Evidence: **B***)

Anesthetic Considerations and Intraoperative Management

Choice of Anesthetic Technique and Agent

Recommendations for Use of Volatile Anesthetic Agents

Class IIa

1. It can be beneficial to use volatile anesthetic agents during noncardiac surgery for the maintenance of general anesthesia in hemodynamically stable patients at risk for myocardial ischemia. (*Level of Evidence:* ***B***)

Prophylactic Intraoperative Nitroglycerin

Class IIb

1. The usefulness of intraoperative nitroglycerin as a prophylactic agent to prevent myocardial ischemia and cardiac morbidity is unclear for high-risk patients undergoing noncardiac surgery, particularly those who have required nitrate therapy to control angina. The recommendation for prophylactic use of nitroglycerin must take into account the anesthetic plan and patient hemodynamics and must recognize that vasodilation and hypovolemia can readily occur during anesthesia and surgery. (*Level of Evidence:* ***C***)

Use of Transesophageal Echocardiography

Class IIa

1. The emergency use of intraoperative or perioperative transesophageal echocardiography is reasonable to determine the cause of an acute, persistent, and life-threatening hemodynamic abnormality. (*Level of Evidence:* ***C***)

Maintenance of Body Temperature

Class I

1. Maintenance of body temperature in a normothermic range is recommended for most procedures other than during periods in which mild hypothermia is intended to provide organ protection (e.g., during high aortic cross-clamping). (*Level of Evidence:* ***B***)

Perioperative Control of Blood Glucose Concentration

Class IIa

1. It is reasonable that blood glucose concentration be controlled* during the perioperative period in patients with diabetes mellitus or acute hyperglycemia who are at high risk for myocardial ischemia or who are undergoing vascular and major noncardiac surgical procedures with planned intensive care unit admission. (*Level of Evidence:* ***B***)

   *Blood glucose levels less than 150 milligrams/deciliter (mg/dL) appear to be beneficial.

Class IIb

1. The usefulness of strict control of blood glucose concentration* during the perioperative period is uncertain in patients with diabetes mellitus or acute

hyperglycemia who are undergoing noncardiac surgical procedures without planned intensive care unit admission. (*Level of Evidence:* ***C***)

Perioperative Surveillance

Intraoperative and Postoperative Use of Pulmonary Artery Catheters (PACs)

Recommendations for Perioperative Use of PACs

Class IIb

1. Use of a PAC may be reasonable in patients at risk for major hemodynamic disturbances that are easily detected by a PAC; however, the decision must be based on 3 parameters: patient disease, surgical procedure (i.e., intraoperative and postoperative fluid shifts), and practice setting (experience in PAC use and interpretation of results), because incorrect interpretation of the data from a PAC may cause harm. (*Level of Evidence:* ***B***)

Class III

1. Routine use of a PAC perioperatively, especially in patients at low risk of developing hemodynamic disturbances, is not recommended. (*Level of Evidence:* ***A***)

Intraoperative and Postoperative Use of ST-Segment Monitoring

Class IIa

1. Intraoperative and postoperative ST-segment monitoring can be useful to monitor patients with known CAD or those undergoing vascular surgery, with computerized ST-segment analysis, when available, used to detect myocardial ischemia during the perioperative period. (*Level of Evidence:* ***B***)

Class IIb

1. Intraoperative and postoperative ST-segment monitoring may be considered in patients with single or multiple risk factors for CAD who are undergoing noncardiac surgery. (*Level of Evidence:* ***B***)

Surveillance for Perioperative MI

Class I

1. Postoperative troponin measurement is recommended in patients with ECG changes or chest pain typical of acute coronary syndrome. (*Level of Evidence:* ***C***)

Class IIb

1. The use of postoperative troponin measurement is not well established in patients who are clinically stable and have undergone vascular and intermediate-risk surgery. (*Level of Evidence:* ***C***)

Class III

1. Postoperative troponin measurement is not recommended in asymptomatic stable patients who have undergone low-risk surgery. (*Level of Evidence:* ***C***)

Definitions:

Applying Classification of Recommendations and Level of Evidence

		SIZE OF TREATMENT EF		
		CLASS I *Benefit >>> Risk* Procedure/Treatment **SHOULD** be performed/ administered	**CLASS IIa** *Benefit >> Risk* *Additional studies with focused objectives needed* **IT IS REASONABLE** to perform procedure/ administer treatment	**CLASS I** *Benefit ≥* *Additiona* *objective* *registry* *helpful* Procedur **BE CONS**
Estimate of Certainty (Precision) of Treatment Effect	**LEVEL A** Multiple (3–5) population risk strata evaluated* General consistency of direction and magnitude of effect	• Recommendation that procedure or treatment is useful/effective • Sufficient evidence from multiple randomized trials or meta-analyses	• Recommendation in favor of treatment of procedure being useful/effective • Some conflicting evidence from multiple randomized trials or meta-analyses	• R u le • G ev m tr ar
	LEVEL B Limited (2–3) population risk strata evaluated*	• Recommendation that procedure or treatment is useful/effective • Limited evidence from single randomized trial or	• Recommendation in favor of treatment of procedure being useful/effective • Some conflicting evidence from single randomized trial or	• R u le • G ev ra no

		SIZE OF TREATMENT EF		
		CLASS I *Benefit >>> Risk* Procedure/Treatment **SHOULD** be performed/ administered	**CLASS IIa** *Benefit >> Risk Additional studies with focused objectives needed* **IT IS REASONABLE** to perform procedure/ administer treatment	**CLASS I** *Benefit ≥ Additiona objective registry helpful* Procedur **BE CONS**
		nonrandomized studies	nonrandomized studies	st
	LEVEL C Very limited (1–2) population risk strata evaluated*	• Recommendation that procedure or treatment is useful/effective • Only expert opinion, case studies, or standard-of-care	• Recommendation in favor of treatment of procedure being useful/effective • Only diverging expert opinion, case studies, or standard-of-care	• R us le • O op or

*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as gender, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use. A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Even though randomized trials are not available, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

NOTE: In 2003, the American College of Cardiology/American Heart Association (ACC/AHA) Task Force on Practice Guidelines developed a list of suggested phrases to use when writing recommendations. All guideline recommendations have been written in full sentences that express a complete thought, such that a recommendation, even if separated and presented apart from the rest of the document (including headings above sets of recommendations), would still convey the full intent of the recommendation. It is hoped that this will increase readers' comprehension of the guidelines and will allow queries at the individual recommendation level. (See Table 1 in the original guideline document for a list of suggested phrases for writing recommendations.)

CLINICAL ALGORITHM(S)

The original guideline document contains clinical algorithms for:

- Cardiac evaluation and care for noncardiac surgery based on active clinical conditions, known cardiovascular disease, or cardiac risk factors for patients 50 years of age or greater
- Proposed approach to the management of patients with previous percutaneous coronary intervention (PCI) who require noncardiac surgery, based on expert opinion
- Treatment for patients requiring PCI who need subsequent surgery

EVIDENCE SUPPORTING THE RECOMMENDATIONS

TYPE OF EVIDENCE SUPPORTING THE RECOMMENDATIONS

The type of supporting evidence is identified and graded for each recommendation (see "Major Recommendations").

BENEFITS/HARMS OF IMPLEMENTING THE GUIDELINE RECOMMENDATIONS

POTENTIAL BENEFITS

- Appropriate use of invasive and noninvasive tests to evaluate cardiac risk in patients undergoing noncardiac surgery
- Decreased perioperative risk and cardiovascular morbidity (e.g., myocardial infarction) and mortality

POTENTIAL HARMS

- Care should be taken in applying recommendations on beta-blocker therapy to patients with decompensated heart failure, nonischemic cardiomyopathy, or severe valvular heart disease in the absence of coronary heart disease.
- Randomized controlled trials are still needed to explore the observation that there may be some harm associated with beta-blocker therapy in low-risk patients.
- Evidence of benefit of pulmonary artery catheter (PAC) use from controlled trials is equivocal, and a large-scale cohort study demonstrated potential harm. The decision to place a PAC should carefully weigh the potential for harm with any potential benefit from the information obtained from the monitor.
- Strategies of myocardial infarction assessment that included the serial measurement of creatine kinase-myocardial band fraction (CK-MB) had higher false-positive rates (i.e., lower specificity) without higher sensitivities. In contrast, a study reported that overall survival was associated with the degree of CK-MB elevation in 348 patients undergoing abdominal aortic aneurysm repair, with higher levels associated with worse survival.

CONTRAINDICATIONS

CONTRAINDICATIONS

- If there is a contraindication to 12 months of dual-antiplatelet therapy, such as planned noncardiac surgery, then drug-eluting stents (DES) should not be implanted.
- Because of the substantial risk of bleeding at the surgical site, patients who have recently undergone surgery have been excluded from all trials of fibrinolytic therapy, and recent surgery is generally considered a strong contraindication to fibrinolytic therapy.

QUALIFYING STATEMENTS

QUALIFYING STATEMENTS

- These guidelines attempt to define practices that meet the needs of most patients in most circumstances. Clinical decision making should consider the quality and availability of expertise in the area where care is provided. These guideline recommendations reflect a consensus of expert opinion after a thorough review of the available, current scientific evidence and are intended to improve patient care.
- Patient adherence to prescribed and agreed on medical regimens and lifestyles is an important aspect of treatment. Prescribed courses of treatment in accordance with these recommendations will only be effective if they are followed. Because lack of patient understanding and adherence may adversely affect treatment outcomes, physicians and other healthcare providers should make every effort to engage the patient in active participation with prescribed medical regimens and lifestyles.
- If these guidelines are used as the basis for regulatory or payer decisions, the ultimate goal is quality of care and serving the patient's best interests. The ultimate judgment regarding care of a particular patient must be made by the healthcare provider and the patient in light of all of the circumstances presented by that patient. There are circumstances in which deviations from these guidelines are appropriate.

Limitations in the Perioperative Beta-Blocker Literature include:

- Most trials are inadequately powered.
- Few randomized trials of medical therapy to prevent perioperative major adverse cardiac events have been performed.
- Few randomized trials have examined the role of perioperative beta-blocker therapy, and there is particularly a lack of trials that focus on high-risk patients.
- Studies to determine the role of beta blockers in intermediate- and low-risk populations are lacking.
- Studies to determine the optimal type of beta blockers are lacking.
- No studies have addressed care-delivery mechanisms in the perioperative setting, identifying how, when, and by whom perioperative beta-blocker therapy should be implemented and monitored.

IMPLEMENTATION OF THE GUIDELINE

DESCRIPTION OF IMPLEMENTATION STRATEGY

An implementation strategy was not provided.

IMPLEMENTATION TOOLS

Clinical Algorithm

For information about availability, see the "Availability of Companion Documents" and "Patient Resources" fields below.

INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

IOM CARE NEED

Living with Illness
Staying Healthy

IOM DOMAIN

Effectiveness

IDENTIFYING INFORMATION AND AVAILABILITY

BIBLIOGRAPHIC SOURCE(S)

Fleisher LA, Beckman JA, Brown KA, Calkins H, Chaikof E, Fleischmann KE, Freeman WK, Froehlich JB, Kasper EK, Kersten JR, Riegel B, Robb JF, Smith SC Jr, Jacobs AK, Adams CD, Anderson JL, Antman EM, Buller CE, Creager MA, Ettinger SM, Faxon DP, Fuster V, Halperin JL, Hiratzka LF, Hunt SA, Lytle BW, Nishimura R, Ornato JP, Page RL, Riegel B, Tarkington LG, Yancy CW, American College of Cardiology, American Heart Association Task Force on Practice Guidelines (writing Committee, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society for Vascular Surgery. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery. J Am Coll Cardiol 2007 Oct 23;50(17):e159-241. [584 references] PubMed

ADAPTATION

Not applicable: The guideline was not adapted from another source.

DATE RELEASED

1996 Mar 15 (revised 2007 Oct)

GUIDELINE DEVELOPER(S)

American College of Cardiology Foundation - Medical Specialty Society
American Heart Association - Professional Association

SOURCE(S) OF FUNDING

The American College of Cardiology Foundation and the American Heart Association. No outside funding accepted.

GUIDELINE COMMITTEE

American College of Cardiology/American Heart Association Task Force on Practice Guidelines

Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery

COMPOSITION OF GROUP THAT AUTHORED THE GUIDELINE

Committee Members: Lee A. Fleisher, MD, FACC, FAHA, *Chair*; Joshua A. Beckman, MD, FACC; Kenneth A. Brown, MD, FACC, FAHA; Hugh Calkins, MD, FACC, FAHA; Elliott Chaikof, MD; Kirsten E. Fleischmann, MD, MPH, FACC; William K. Freeman, MD, FACC; James B. Froehlich, MD, MPH, FACC; Edward K. Kasper, MD, FACC; Judy R. Kersten, MD, FACC; Barbara Riegel, DNSc, RN, FAHA; John F. Robb, MD, FACC

Task Force Members: Sidney C. Smith, JR., MD, FACC, FAHA, *Chair*; Alice K. Jacobs, MD, FACC, FAHA, *Vice-Chair*; Cynthia D. Adams, MSN, PhD, FAHA; Jeffrey L. Anderson, MD, FACC, FAHA; Elliott M. Antman, MD, FACC, FAHA; Christopher E. Buller, MD, FACC; Mark A. Creager, MD, FACC, FAHA; Steven M. Ettinger, MD, FACC; David P. Faxon, MD, FACC, FAHA; Valentin Fuster, MD, PhD, FACC, FAHA, FESC; Jonathan L. Halperin, MD, FACC, FAHA; Loren F. Hiratzka, MD, FACC, FAHA; Sharon A. Hunt, MD, FACC, FAHA; Bruce W. Lytle, MD, FACC, FAHA; Rick Nishimura, MD, FACC, FAHA; Joseph P. Ornato, MD, FACC, FAHA; Richard L. Page, MD, FACC, FAHA; Barbara Riegel, DNSc, RN, FAHA*; Lynn G. Tarkington, RN; Clyde W. Yancy, MD, FACC

**Former Task Force member during this writing effort*

FINANCIAL DISCLOSURES/CONFLICTS OF INTEREST

The American College of Cardiology/American Heart Association (ACC/AHA) Task Force on Practice Guidelines makes every effort to avoid any actual, potential, or perceived conflict of interest that might arise as a result of an industry relationship or personal interest of the writing committee. Specifically, all members of the writing committee, as well as peer reviewers of the document, were asked to provide disclosure statements of all such relationships that might be perceived as real or potential conflicts of interest. Writing committee members were also strongly encouraged to declare a previous relationship with industry that may be perceived as relevant to guideline development. If a writing committee member developed a new relationship with industry during their tenure, they are required to notify guideline staff in writing. The continued participation of the writing committee member was reviewed. These statements were reviewed by the parent task force, reported orally to all members of the

writing committee at each meeting, and updated and reviewed by the writing committee as changes occurred.

Table: ACC/AHA Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery: Author Relationships With Industry

Committee Member	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Other
Joshua A. Beckman	Bristol-Myers Squibb	None	Sanofi-Aventis	Bristol-Myers Squibb*; Merck; Eli Lilly; Sanofi-Aventis*	None
Kenneth A. Brown	GE Healthcare	None	None	None	None
Hugh Calkins	None	None	None	None	None
Elliot Chaikof	None	None	None	None	None
Kirsten E. Fleischmann	None	None	None	None	Pfizer (QI/CME Initiatives)
Lee A. Fleisher	None	None	None	None	None
William K. Freeman	None	None	None	None	None
James B. Froehlich	Pfizer	None	Sanofi-Aventis	Sanofi-Aventis; Otsuka; Pfizer; Merck	None
Edward K. Kasper	Scios	None	None	None	None
Judy R. Kersten	Abbott Laboratories	Abbott Laboratories*	None	Abbott Laboratories*	None

Committee Member	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Other
Barbara Riegel	None	None	None	None	None
John F. Robb	None	None	None	None	None

This table represents the actual or potential relationships with industry that were reported on May 11, 2007. This table was updated in conjunction with all meetings and conference calls of the writing committee. QI/CME indicates quality improvement/continuing medical education.
*Significant relationship (greater than $10,000)

See Appendix II in the original guideline document for peer reviewer relationships with industry.

GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: American College of Cardiology Foundation (ACCF), American Heart Association (AHA). ACC/AHA guideline update on perioperative cardiovascular evaluation for noncardiac surgery. A report of the American College of Cardiology/American Heart Association Task Force on practice guidelines (Committee to Update the 1996 Guidelines). Bethesda (MD): American College of Cardiology Foundation; 2002. 58 p. [390 references]

Fleisher LA, Beckman JA, Freeman WK, Brown KA, Froeclich JB, Calkins H, Kasper EK, Chaikof E, Kersten JR, Fleischmann KE, Riegel B. ACC/AHA 2006 guideline update on perioperative cardiovascular evaluation on noncardiac surgery: focused update on perioperative beta-blocker therapy. A report of the American College of Cardiology/American Heart Association Task Force on Practice [trunc]. J Am Coll Cardiol 2006;47:1-12. [25 references]

GUIDELINE AVAILABILITY

Electronic copies: Available in Portable Document Format (PDF) from the American College of Cardiology (ACC) Web site; electronic copies are also available in PDF from the American Heart Association (AHA) Web site

Print copies: Available from the American College of Cardiology, Resource Center, 9111 Old Georgetown Rd, Bethesda, MD 20814-1699; (800) 253-4636 (US only).

AVAILABILITY OF COMPANION DOCUMENTS

The following is available:

- ACC/AHA/ESC 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery - executive summary. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). J Am Coll Cardiol 2007 Oct;50(17):1707-32. Electronic copies: Available from the American College of Cardiology (ACC) Web site. Also available in PDF from the American Heart Association (AHA) Web site.

Print copies: Available from the American College of Cardiology, Resource Center, 9111 Old Georgetown Rd, Bethesda, MD 20814-1699; (800) 253-4636 (US only).

PATIENT RESOURCES

None available

NGC STATUS

This summary was completed by ECRI on June 30, 1998. The information was verified by the guideline developer on December 1, 1998. This summary was updated by ECRI on April 30, 2002. The updated information was verified by the guideline developer on August 7, 2002. This NGC summary was updated on May 12, 2006. The updated information was verified by the guideline developer on June 15, 2006. This summary was updated by ECRI on March 6, 2007 following the U.S. Food and Drug Administration (FDA) advisory on Coumadin (warfarin sodium). This summary was updated by ECRI Institute on July 12, 2007 following the U.S. Food and Drug Administration (FDA) advisory on Troponin-1 Immunoassay. This summary was updated by ECRI Institute on September 7, 2007 following the revised U.S. Food and Drug Administration (FDA) advisory on Coumadin (warfarin). This NGC summary was updated by ECRI Institute on November 20, 2007. The updated information was verified by the guideline developer on January 7, 2008.

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