2011 ACCF/AHA guideline for coronary artery bypass graft surgery: Executive summary

A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines

Developed in Collaboration With The American Association for Thoracic Surgery, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons

Writing Committee Members*: L. David Hillis, MD, FACC, *Chair,*[†] Peter K. Smith, MD, FACC, *Vice Chair,*[*,†] Jeffrey L. Anderson, MD, FACC, FAHA,[*,‡] John A. Bittl, MD, FACC,[§] Charles R. Bridges, MD, ScD, FACC, FAHA,[*,†] John G. Byrne, MD, FACC,[†] Joaquin E. Cigarroa, MD, FACC,[†] Verdi J. DiSesa, MD, FACC,[†] Loren F. Hiratzka, MD, FACC, FAHA,[†] Adolph M. Hutter, Jr, MD, MACC, FAHA,[†] Michael E. Jessen, MD, FACC,[*,†] Ellen C. Keeley, MD, MS,[†] Stephen J. Lahey, MD,[†] Richard A. Lange, MD, FACC, FAHA,[†,§] Martin J. London, MD,[‖] Michael J. Mack, MD, FACC,[*,¶] Manesh R. Patel, MD, FACC,[†] John D. Puskas, MD, FACC,[*,†] Joseph F. Sabik, MD, FACC,[*,#] Ola Selnes, PhD,[†] David M. Shahian, MD, FACC, FAHA,[**] Jeffrey C. Trost, MD, FACC,[*,†] Michael D. Winniford, MD, FACC[†]

ACCF/AHA Task Force Members: Alice K. Jacobs, MD, FACC, FAHA, *Chair,* Jeffrey L. Anderson, MD, FACC, FAHA, *Chair-Elect,* Nancy Albert, PhD, CCNS, CCRN, FAHA, Mark A. Creager, MD, FACC, FAHA, Steven M. Ettinger, MD, FACC, Robert A. Guyton, MD, FACC, Jonathan L. Halperin, MD, FACC, FAHA, Judith S. Hochman, MD, FACC, FAHA, Frederick G. Kushner, MD, FACC, FAHA, E. Magnus Ohman, MD, FACC, William Stevenson, MD, FACC, FAHA, Clyde W. Yancy, MD, FACC, FAHA

* Writing committee members are required to recuse themselves from voting on sections to which their specific relationships with industry and other entities may apply; see Appendix 1 for recusal information. † ACCF/AHA Representative. ‡ ACCF/AHA Task Force on Practice Guidelines Liaison. § Joint Revascularization Section Author. ‖ Society of Cardiovascular Anesthesiologists Representative. ¶ American Association for Thoracic Surgery Representative. # Society of Thoracic Surgeons Representative. ** ACCF/AHA Task Force on Performance Measures Liaison.

This document was approved by the American College of Cardiology Foundation Board of Trustees and American Heart Association Science Advisory and Coordinating Committee in July 2011, by the Society of Cardiovascular Anesthesiologists and Society of Thoracic Surgeons in August 2011, and by The American Association for Thoracic Surgery in September 2011.

The American Association of Thoracic Surgery requests that this document be cited as follows: Hillis LD, Smith PK, Anderson JL, Bittl JA, Bridges CR, Byrne JG, Cigarroa JE, DiSesa VJ, Hiratzka LF, Hutter AM Jr, Jessen ME, Keeley EC, Lahey SJ, Lange RA, London MJ, Mack MJ, Patel MR, Puskas JD, Sabik JF, Selnes O, Shahian DM, Trost JC, Winniford MD. 2011 ACCF/AHA guideline for coronary artery bypass graft surgery: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Thorac Cardiovasc Surg.* 2012;143:4-34.

This article is copublished in *Circulation, Anesthesia & Analgesia,* and the *Journal of the American College of Cardiology.*

Copies: This document is available on the World Wide Web sites of the American College of Cardiology (www.cardiosource.org), and the American Heart Association (my.americanheart.org). For copies of this document, please contact the Elsevier Inc. Reprint Department, fax (212) 633-3820, e-mail reprints@elsevier.com.

0022-5223/$36.00

doi:10.1016/j.jtcvs.2011.10.015

TABLE OF CONTENTS

PREAMBLE

The medical profession should play a central role in evaluating the evidence related to drugs, devices, and procedures for the detection, management, and prevention of disease. When properly applied, expert analysis of available data on the benefits and risks of these therapies and procedures can improve the quality of care, optimize patient outcomes, and favorably affect costs by focusing resources on the most effective strategies. An organized and directed approach to a thorough review of evidence has resulted in the production of clinical practice guidelines that assist physicians in selecting the best management strategy for an individual patient. Moreover, clinical practice guidelines can provide a foundation for other applications, such as performance measures, appropriate use criteria, and both quality improvement and clinical decision support tools.

The American College of Cardiology Foundation (ACCF) and the American Heart Association (AHA) have jointly produced guidelines in the area of cardiovascular disease since 1980. The ACCF/AHA Task Force on Practice Guidelines (Task Force), charged with developing, updating, and revising practice guidelines for cardiovascular diseases and procedures, directs and oversees this effort. Writing committees are charged with regularly reviewing and evaluating all available evidence to develop balanced, patient-centric recommendations for clinical practice.

Experts in the subject under consideration are selected by the ACCF and AHA to examine subject-specific data and write guidelines in partnership with representatives from other medical organizations and specialty groups. Writing committees are asked to perform a formal literature review;

TABLE 1. Applying classification of recommendations and level of evidence

ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT	SIZE OF TREATMENT EFFECT			
	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 IIb** *Benefit ≥ Risk* *Additional studies with broad objectives needed; additional registry data would be helpful* Procedure/Treatment **MAY BE CONSIDERED**	**CLASS III** *No Benefit* or **CLASS III** *Harm* Procedure/ Test / Treatment COR III: No benefit — Not Helpful — No Proven Benefit COR III: Harm — Excess Cost w/o Benefit or Harmful — Harmful to Patients
LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	■ Recommendation that procedure or treatment is useful/effective ■ Sufficient evidence from multiple randomized trials or meta-analyses	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Sufficient evidence from multiple randomized trials or meta-analyses
LEVEL B Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is useful/effective ■ Evidence from single randomized trial or nonrandomized studies	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Evidence from single randomized trial or nonrandomized studies
LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care	■ Recommendation that procedure or treatment is useful/effective ■ Only expert opinion, case studies, or standard of care	■ Recommendation in favor of treatment or procedure being useful/effective ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation's usefulness/efficacy less well established ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Only expert opinion, case studies, or standard of care
Suggested phrases for writing recommendations	should is recommended is indicated is useful/effective/beneficial	is reasonable can be useful/effective/beneficial is probably recommended or indicated	may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established	COR III: No Benefit: is not recommended; is not indicated; should not be performed/ administered/ other; is not useful/ beneficial/ effective COR III: Harm: potentially harmful; causes harm; associated with excess morbidity/mortality; should not be performed/ administered/ other
Comparative effectiveness phrases†	treatment/strategy A is recommended/indicated in preference to treatment B treatment A should be chosen over treatment B	treatment/strategy A is probably recommended/indicated in preference to treatment B it is reasonable to choose treatment A over treatment B		

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. Although randomized trials are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective. *Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as sex, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use. †For comparative effectiveness recommendations (Class I and IIa; Level of Evidence A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

weigh the strength of evidence for or against particular tests, treatments, or procedures; and include estimates of expected outcomes where such data exist. Patient-specific modifiers, comorbidities, and issues of patient preference that may influence the choice of tests or therapies are considered. When available, information from studies on cost is considered, but data on efficacy and outcomes constitute the primary basis for the recommendations contained herein.

In analyzing the data and developing recommendations and supporting text, the writing committee uses evidence-based methodologies developed by the Task Force.[1] The Class of Recommendation (COR) is an estimate of the size of the treatment effect considering risks versus benefits in addition to evidence and/or agreement that a given treatment or procedure is or is not useful/effective or in some situations may cause harm. The Level of Evidence (LOE) is an estimate of the certainty or precision of the treatment effect. The writing committee reviews and ranks evidence supporting each recommendation with the weight of evidence ranked as LOE A, B, or C according to specific definitions that are included in Table 1. Studies are identified as observational, retrospective, prospective, or randomized where appropriate. For certain conditions for which inadequate data are available, recommendations are based on expert consensus and clinical experience and are ranked

as LOE C. When recommendations at LOE C are supported by historical clinical data, appropriate references (including clinical reviews) are cited if available. For issues for which sparse data are available, a survey of current practice among the clinicians on the writing committee is the basis for LOE C recommendations, and no references are cited. The schema for COR and LOE is summarized in Table 1, which also provides suggested phrases for writing recommendations within each COR. A new addition to this methodology is separation of the Class III recommendations to delineate if the recommendation is determined to be of ''no benefit'' or is associated with ''harm'' to the patient. In addition, in view of the increasing number of comparative effectiveness studies, comparator verbs and suggested phrases for writing recommendations for the comparative effectiveness of one treatment or strategy versus another have been added for COR I and IIa, LOE A or B only.

In view of the advances in medical therapy across the spectrum of cardiovascular diseases, the Task Force has designated the term *guideline-directed medical therapy (GDMT)* to represent optimal medical therapy as defined by ACCF/AHA guideline-recommended therapies (primarily Class I). This new term, GDMT, will be used herein and throughout all future guidelines.

Because the ACCF/AHA practice guidelines address patient populations (and healthcare providers) residing in North America, drugs that are not currently available in North America are discussed in the text without a specific COR. For studies performed in large numbers of subjects outside North America, each writing committee reviews the potential influence of different practice patterns and patient populations on the treatment effect and relevance to the ACCF/AHA target population to determine whether the findings should inform a specific recommendation.

The ACCF/AHA practice guidelines are intended to assist healthcare providers in clinical decision making by describing a range of generally acceptable approaches to the diagnosis, management, and prevention of specific diseases or conditions. The guidelines attempt to define practices that meet the needs of most patients in most circumstances. The ultimate judgment regarding the care of a particular patient must be made by the healthcare provider and patient in light of all the circumstances presented by that patient. As a result, situations may arise for which deviations from these guidelines may be appropriate. Clinical decision making should involve consideration of the quality and availability of expertise in the area where care is provided. When these guidelines are used as the basis for regulatory or payer decisions, the goal should be improvement in quality of care. The Task Force recognizes that situations arise in which additional data are needed to inform patient care more effectively; these areas will be identified within each respective guideline when appropriate.

Prescribed courses of treatment in accordance with these recommendations are effective only if followed. Because lack of patient understanding and adherence may adversely affect outcomes, physicians and other healthcare providers should make every effort to engage the patient's active participation in prescribed medical regimens and lifestyles. In addition, patients should be informed of the risks, benefits, and alternatives to a particular treatment and be involved in shared decision making whenever feasible, particularly for COR IIa and IIb, where the benefit-to-risk ratio may be lower.

The Task Force makes every effort to avoid actual, potential, or perceived conflicts of interest that may arise as a result of industry relationships or personal interests among the members of the writing committee. All writing committee members and peer reviewers of the guideline are required to disclose all such current relationships, as well as those existing 12 months previously. In December 2009, the ACCF and AHA implemented a new policy for relationships with industry and other entities (RWI) that requires the writing committee chair plus a minimum of 50% of the writing committee to have no *relevant* RWI (Appendix 1 for the ACCF/AHA definition of relevance). These statements are reviewed by the Task Force and all members during each conference call and meeting of the writing committee and are updated as changes occur. All guideline recommendations require a confidential vote by the writing committee and must be approved by a consensus of the voting members. Members are not permitted to write, and must rescue themselves from voting on, any recommendation or section to which their RWI apply. Members who recused themselves from voting are indicated in the list of writing committee members, and section recusals are noted in Appendix 1. Authors' and peer reviewers' RWI pertinent to this guideline are disclosed in Appendixes 1 and 2, respectively. Additionally, to ensure complete transparency, writing committee members' comprehensive disclosure information—including RWI not pertinent to this document—is available as an online supplement. Comprehensive disclosure information for the Task Force is also available online at www.cardiosource.org/ACC/About-ACC/Leadership/Guidelines-and-Documents-Task-Forces.aspx. The work of the writing committee was supported exclusively by the ACCF and AHA without commercial support. Writing committee members volunteered their time for this activity.

In an effort to maintain relevance at the point of care for practicing physicians, the Task Force continues to oversee an ongoing process improvement initiative. As a result, in response to pilot projects, evidence tables (with references linked to abstracts in PubMed) have been added.

In April 2011, the Institute of Medicine released 2 reports: *Finding What Works in Health Care: Standards for Systematic Reviews* and *Clinical Practice Guidelines We Can Trust*.[2,3] It is noteworthy that the ACCF/AHA

guidelines are cited as being compliant with many of the proposed standards. A thorough review of these reports and of our current methodology is under way, with further enhancements anticipated.

The recommendations in this guideline are considered current until they are superseded by a focused update or the full-text guideline is revised. Guidelines are official policy of both the ACCF and AHA.

Alice K. Jacobs, MD, FACC, FAHA
Chair, ACCF/AHA Task Force on Practice Guidelines

1. INTRODUCTION

1.1. Methodology and Evidence Review

Whenever possible, the recommendations listed in this document are evidence based. Articles reviewed in this guideline revision covered evidence from the past 10 years through January 2011, as well as selected other references through April 2011. Searches were limited to studies, reviews, and evidence conducted in human subjects that were published in English. Key search words included but were not limited to: *analgesia, anastomotic techniques, antiplatelet agents, automated proximal clampless anastomosis device, asymptomatic ischemia, Cardica C-port, cost effectiveness, depressed left ventricular (LV) function, distal anastomotic techniques, direct proximal anastomosis on aorta, distal anastomotic devices, emergency coronary artery bypass graft (CABG) and ST-elevation myocardial infarction (STEMI), heart failure, interrupted sutures, LV systolic dysfunction, magnetic connectors, PAS-Port automated proximal clampless anastomotic device, patency, proximal connectors, renal disease, sequential anastomosis, sternotomy, symmetry connector, symptomatic ischemia, proximal connectors, sequential anastomosis, T grafts, thoracotomy, U-clips, Ventrica Magnetic Vascular Port system, Y grafts*. Additionally, the committee reviewed documents related to the subject matter previously published by the ACCF and AHA. References selected and published in this document are representative but not all-inclusive.

The guideline is focused on the safe, appropriate, and efficacious performance of CABG. The STEMI, percutaneous coronary intervention (PCI), and CABG guidelines were written concurrently, with additional collaboration from the Stable Ischemic Heart Disease (SIHD) guideline writing committee. This allowed greater collaboration among the different writing committees on topics such as PCI in STEMI and revascularization strategies in patients with coronary artery disease (CAD) (including unprotected left main PCI, multivessel disease revascularization, and hybrid procedures).

In accordance with the direction of the Task Force and feedback from readers, in this iteration of the guideline, the amount of text has been shortened, and emphasis has been placed on summary statements rather than detailed discussion of numerous individual trials. Online supplemental evidence and summary tables have been created to document the studies and data considered for new or changed guideline recommendations.

Because the executive summary contains only the recommendations, the reader is encouraged to consult the full-text guideline[4] for additional detail on the recommendations and guidance on the care of the patient undergoing CABG.

1.2. Organization of the Writing Committee

The committee was composed of acknowledged experts in CABG, interventional cardiology, general cardiology, and cardiovascular anesthesiology. The committee included representatives from the ACCF, AHA, American Association for Thoracic Surgery, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons (STS).

1.3. Document Review and Approval

This document was reviewed by 2 official reviewers, each nominated by both the ACCF and the AHA, as well as 1 reviewer each from the American Association for Thoracic Surgery, Society of Cardiovascular Anesthesiologists, and STS, as well as members from the ACCF/AHA Task Force on Data Standards, ACCF/AHA Task Force on Performance Measures, ACCF Surgeons' Scientific Council, ACCF Interventional Scientific Council, and Southern Thoracic Surgical Association. All information on reviewers' RWIs was distributed to the writing committee and is published in this document (Appendix 2. This document was approved for publication by the governing bodies of the ACCF and the AHA and endorsed by the American Association for Thoracic Surgery, Society of Cardiovascular Anesthesiologists, and STS.

2. PROCEDURAL CONSIDERATIONS: RECOMMENDATIONS

2.1. Anesthetic Considerations

Class I

1. **Anesthetic management directed toward early postoperative extubation and accelerated recovery of low- to medium-risk patients undergoing uncomplicated CABG is recommended.[5-7] *(Level of Evidence: B)***
2. **Multidisciplinary efforts are indicated to ensure an optimal level of analgesia and patient comfort throughout the perioperative period.[8-12] *(Level of Evidence: B)***
3. **Efforts are recommended to improve interdisciplinary communication and patient safety in the perioperative environment (eg, formalized checklist-guided multidisciplinary communication).[13-16] *(Level of Evidence: B)***
4. **A fellowship-trained cardiac anesthesiologist (or experienced board-certified practitioner) credentialed in the use of perioperative transesophageal echocardiography is recommended to provide or supervise anesthetic care of patients who are considered to be at high risk.[17-19] *(Level of Evidence: C)***

Class IIa

1. Volatile anesthestic-based regimens can be useful in facilitating early extubation and reducing patient recall.[6,20-22] *(Level of Evidence: A)*

Class IIb

1. The effectiveness of high thoracic epidural anesthesia/analgesia for routine analgesic use is uncertain.[23-26] *(Level of Evidence: B)*

Class III: Harm

1. Cyclooxygenase-2 inhibitors are not recommended for pain relief in the postoperative period after CABG.[27,28] *(Level of Evidence: B)*
2. Routine use of early extubation strategies in facilities with limited backup for airway emergencies or advanced respiratory support is potentially harmful. *(Level of Evidence: C)*

2.2. Bypass Graft Conduit

Class I

1. If possible, the left internal mammary artery (LIMA) should be used to bypass the left anterior descending (LAD) artery when bypass of the LAD artery is indicated.[29-32] *(Level of Evidence: B)*

Class IIa

1. The right internal mammary artery is probably indicated to bypass the LAD artery when the LIMA is unavailable or unsuitable as a bypass conduit. *(Level of Evidence: C)*
2. When anatomically and clinically suitable, use of a second internal mammary artery to graft the left circumflex or right coronary artery (when critically stenosed and perfusing LV myocardium) is reasonable to improve the likelihood of survival and to decrease reintervention.[33-37] *(Level of Evidence: B)*

Class IIb

1. Complete arterial revascularization may be reasonable in patients less than or equal to 60 years of age with few or no comorbidities. *(Level of Evidence: C)*
2. Arterial grafting of the right coronary artery may be reasonable when a critical (≥90%) stenosis is present.[32,36,38] *(Level of Evidence: B)*
3. Use of a radial artery graft may be reasonable when grafting left-sided coronary arteries with severe stenoses (>70%) and right-sided arteries with critical stenoses (≥90%) that perfuse LV myocardium.[39-44] *(Level of Evidence: B)*

Class III: Harm

1. An arterial graft should not be used to bypass the right coronary artery with less than a critical stenosis (<90%).[32] *(Level of Evidence: C)*

2.3. Intraoperative Transesophageal Echocardiography

Class I

1. Intraoperative transesophageal echocardiography should be performed for evaluation of acute, persistent, and life-threatening hemodynamic disturbances that have not responded to treatment.[45,46] *(Level of Evidence: B)*
2. Intraoperative transesophageal echocardiography should be performed in patients undergoing concomitant valvular surgery.[45,47] *(Level of Evidence: B)*

Class IIa

1. Intraoperative transesophageal echocardiography is reasonable for monitoring of hemodynamic status, ventricular function, regional wall motion, and valvular function in patients undergoing CABG.[46,48-53] *(Level of Evidence: B)*

2.4. Preconditioning/Management of Myocardial Ischemia

Class I

1. Management targeted at optimizing the determinants of coronary arterial perfusion (eg, heart rate, diastolic or mean arterial pressure, and right ventricular or LV end-diastolic pressure) is recommended to reduce the risk of perioperative myocardial ischemia and infarction.[54-58] *(Level of Evidence: B)*

Class IIa

1. Volatile-based anesthesia can be useful in reducing the risk of perioperative myocardial ischemia and infarction.[59-62] *(Level of Evidence: A)*

Class IIb

1. The effectiveness of prophylactic pharmacological therapies or controlled reperfusion strategies aimed at inducing preconditioning or attenuating the adverse consequences of myocardial reperfusion injury or surgically induced systemic inflammation is uncertain.[63-70] *(Level of Evidence: A)*
2. Mechanical preconditioning might be considered to reduce the risk of perioperative myocardial ischemia and infarction in patients undergoing off-pump CABG.[71-73] *(Level of Evidence: B)*
3. Remote ischemic preconditioning strategies using peripheral-extremity occlusion/reperfusion might be considered to attenuate the adverse consequences of myocardial reperfusion injury.[74-76] *(Level of Evidence: B)*
4. The effectiveness of postconditioning strategies to attenuate the adverse consequences of myocardial reperfusion injury is uncertain.[77,78] *(Level of Evidence: C)*

2.5. Clinical Subsets

2.5.1. CABG in Patients With Acute Myocardial Infarction

Class I

1. Emergency CABG is recommended in patients with acute myocardial infarction (MI) in whom (1) primary PCI has failed or cannot be performed, (2) coronary anatomy is suitable for CABG, and (3) persistent ischemia of a significant area of myocardium at rest and/or hemodynamic instability refractory to nonsurgical therapy is present.[79-83] *(Level of Evidence: B)*
2. Emergency CABG is recommended in patients undergoing surgical repair of a postinfarction mechanical complication of MI, such as ventricular septal rupture, mitral valve insufficiency because of papillary muscle infarction and/or rupture, or free wall rupture.[84-88] *(Level of Evidence: B)*

3. **Emergency CABG is recommended in patients with cardiogenic shock and who are suitable for CABG irrespective of the time interval from MI to onset of shock and time from MI to CABG.[82,89-91] *(Level of Evidence: B)***
4. **Emergency CABG is recommended in patients with life-threatening ventricular arrhythmias (believed to be ischemic in origin) in the presence of left main stenosis greater than or equal to 50% and/or 3-vessel CAD.[92] *(Level of Evidence: C)***

Class IIa

1. **The use of CABG is reasonable as a revascularization strategy in patients with multivessel CAD with recurrent angina or MI within the first 48 hours of STEMI presentation as an alternative to a more delayed strategy.[79,81,83,93] *(Level of Evidence: B)***
2. **Early revascularization with PCI or CABG is reasonable for selected patients greater than 75 years of age with ST-segment elevation or left bundle branch block who are suitable for revascularization irrespective of the time interval from MI to onset of shock.[94-98] *(Level of Evidence: B)***

Class III: Harm

1. **Emergency CABG should not be performed in patients with persistent angina and a small area of viable myocardium who are stable hemodynamically. *(Level of Evidence: C)***
2. **Emergency CABG should not be performed in patients with no-reflow (successful epicardial reperfusion with unsuccessful microvascular reperfusion). *(Level of Evidence: C)***

2.5.2. Life-Threatening Ventricular Arrhythmias

Class I

1. **CABG is recommended in patients with resuscitated sudden cardiac death or sustained ventricular tachycardia thought to be caused by significant CAD (≥50% stenosis of left main coronary artery and/or ≥70% stenosis of 1, 2, or all 3 epicardial coronary arteries) and resultant myocardial ischemia.[92,99,100] *(Level of Evidence: B)***

Class III: Harm

1. **CABG should not be performed in patients with ventricular tachycardia with scar and no evidence of ischemia. *(Level of Evidence: C)***

2.5.3. Emergency CABG After Failed PCI

Class I

1. **Emergency CABG is recommended after failed PCI in the presence of ongoing ischemia or threatened occlusion with substantial myocardium at risk.[101,102] *(Level of Evidence: B)***
2. **Emergency CABG is recommended after failed PCI for hemodynamic compromise in patients without impairment of the coagulation system and without a previous sternotomy.[101,103,104] *(Level of Evidence: B)***

Class IIa

1. **Emergency CABG is reasonable after failed PCI for retrieval of a foreign body (most likely a fractured guidewire or stent) in a crucial anatomic location. *(Level of Evidence: C)***
2. **Emergency CABG can be beneficial after failed PCI for hemodynamic compromise in patients with impairment of the coagulation system and without previous sternotomy. *(Level of Evidence: C)***

Class IIb

1. **Emergency CABG might be considered after failed PCI for hemodynamic compromise in patients with previous sternotomy. *(Level of Evidence: C)***

Class III: Harm

1. **Emergency CABG should not be performed after failed PCI in the absence of ischemia or threatened occlusion. *(Level of Evidence: C)***
2. **Emergency CABG should not be performed after failed PCI if revascularization is impossible because of target anatomy or a no-reflow state. *(Level of Evidence: C)***

2.5.4. CABG in Association With Other Cardiac Procedures

Class I

1. **CABG is recommended in patients undergoing noncoronary cardiac surgery with greater than or equal to 50% luminal diameter narrowing of the left main coronary artery or greater than or equal to 70% luminal diameter narrowing of other major coronary arteries. *(Level of Evidence: C)***

Class IIa

1. **The use of the LIMA is reasonable to bypass a significantly narrowed LAD artery in patients undergoing noncoronary cardiac surgery. *(Level of Evidence: C)***
2. **CABG of moderately diseased coronary arteries (>50% luminal diameter narrowing) is reasonable in patients undergoing noncoronary cardiac surgery. (*Level of Evidence: C)***

3. CAD REVASCULARIZATION: RECOMMENDATIONS

Recommendations and text in this section are the result of extensive collaborative discussions between the PCI and CABG writing committees as well as key members of the SIHD and Unstable Angina/Non-ST-Elevation Myocardial Infarction (UA/NSTEMI) writing committees. Certain issues, such as older versus more contemporary studies, primary analyses versus subgroup analyses, and prospective versus post hoc analyses, have been carefully weighed in designating COR and LOE; they are addressed in the appropriate corresponding text.[4]

The goals of revascularization for patients with CAD are to (1) to improve survival and (2) to relieve symptoms. The following text contains recommendations for revascularization toimprove survival and symptoms. These recommendations are summarized in Tables 2 and 3.

Revascularization recommendations in this section are predominantly based on studies of patients with symptomatic SIHD and should be interpreted in this context. As discussed later in this section, recommendations on the type of revascularization are, in general, applicable to patients with UA/NSTEMI. In some cases (eg, unprotected left main

TABLE 2. Revascularization to improve survival compared with medical therapy

Anatomic Setting	COR	LOE	References
UPLM or complex CAD			
CABG and PCI	I—Heart Team approach recommended	C	(105–107)
CABG and PCI	IIa—Calculation of the STS and SYNTAX scores	B	(107–114)
UPLM*			
CABG	I	B	(115–121)
PCI	IIa—For SIHD when *both* of the following are present: • Anatomic conditions associated with a low risk of PCI procedural complications and a high likelihood of good long-term outcome (eg, a low SYNTAX score of ≤22, ostial or trunk left main CAD) • Clinical characteristics that predict a significantly increased risk of adverse surgical outcomes (eg, STS-predicted risk of operative mortality ≥5%)	B	(108,110,111,122–140,168)
	IIa—For UA/NSTEMI if not a CABG candidate	B	(111,127,129–131,136,137,139,140,142)
	IIa—For STEMI when distal coronary flow is TIMI flow grade 3 and PCI can be performed more rapidly and safely than CABG	C	(124,143,144)
	IIb—For SIHD when *both* of the following are present: • Anatomic conditions associated with a low to intermediate risk of PCI procedural complications and intermediate to high likelihood of good long-term outcome (eg, low–intermediate SYNTAX score of <33, bifurcation left main CAD) • Clinical characteristics that predict an increased risk of adverse surgical outcomes (eg, moderate–severe COPD, disability from prior stroke, or prior cardiac surgery; STS-predicted risk of operative mortality >2%)	B	(108,110,111,122–137,139,145)
	III: Harm—For SIHD in patients (versus performing CABG) with unfavorable anatomy and for PCI and who are good candidates for CABG	B	(108,110,111,115–123)
3-vessel disease with or without proximal LAD artery disease*			
CABG	I	B	(117,121,146–149)
	IIa—It is reasonable to choose CABG over PCI in patients with complex 3-vessel CAD (eg, SYNTAX >22) who are good candidates for CABG	B	(123,138,148,164–165)
PCI	IIb—Of uncertain benefit	B	(117,146,148,176)
2-vessel disease with proximal LAD artery disease*			
CABG	I	B	(117,121,146–149)
PCI	IIb—Of uncertain benefit	B	(117,146,148,176)
2-vessel disease without proximal LAD artery disease*			
CABG	IIa—With extensive ischemia	B	(153–156)
	IIb—Of uncertain benefit without extensive ischemia	C	(148)
PCI	IIb—Of uncertain benefit	B	(117,146,148,176)
1-vessel proximal LAD artery disease			
CABG	IIa—With LIMA for long-term benefit	B	(30,31,121,148)
PCI	IIb—of uncertain benefit	B	(117,146,148,176)
1-vessel disease without proximal LAD artery involvement			
CABG	III: Harm	B	(121,146,153,154,188–192)
PCI	III: Harm	B	(121,146,153,154,188–192)
LV dysfunction			
CABG	IIa—EF 35% to 50%	B	(121,157–161)
CABG	IIb—EF <35% without significant left main CAD	B	(121, 157–161,177,178)
PCI	Insufficient data		
Survivors of sudden cardiac death with presumed ischemia-mediated VT			
CABG	I	B	(99,150,152)
PCI	I	C	(150)
No anatomic or physiological criteria for revascularization			
CABG	III: Harm	B	(121,146,153,154,188–192)
PCI	III: Harm	B	(121,146,153,154,188–192)

CABG, Coronary artery bypass graft; *CAD,* coronary artery disease; *COPD,* chronic obstructive pulmonary disease; *COR,* class of recommendation; *EF,* ejection fraction; *LAD,* left anterior descending; *LIMA,* left internal mammary artery; *LOE,* level of evidence; *LV,* left ventricular; *N/A,* not applicable; *PCI,* percutaneous coronary intervention; *SIHD,* stable ischemic heart disease; *STEMI,* ST-elevation myocardial infarction; *STS,* Society of Thoracic Surgeons; *SYNTAX,* Synergy between percutaneous coronary intervention with TAXUS and cardiac surgery; *TIMI,* Thrombolysis In Myocardial Infarction; *UA/NSTEMI,* unstable angina/non–ST-elevation myocardial infarction; *UPLM,* unprotected left main; *VT,* ventricular tachycardia. *In patients with multivessel disease who also have diabetes, it is reasonable to choose CABG (with LIMA) over PCI[155,168-175] *(Class IIa/LOE: B).*

TABLE 3. Revascularization to improve symptoms with significant anatomic (≥50% left main or ≥70% non–left main CAD) or physiological (FFR≤0.80) coronary artery stenoses

Clinical Setting	COR	LOE	References
≥1 significant stenoses amenable to revascularization and unacceptable angina despite GDMT	I—CABG I—PCI	A	(176,193–202)
≥1 significant stenoses and unacceptable angina in whom GDMT cannot be implemented because of medication contraindications, adverse effects, or patient preferences	IIa—CABG IIa—PCI	C	N/A
Previous CABG with ≥1 significant stenoses associated with ischemia and unacceptable angina despite GDMT	IIa—PCI	C	(180,183,186)
	IIb—CABG	C	(187)
Complex 3-vessel CAD (eg, SYNTAX score >22) with or without involvement of the proximal LAD artery and a good candidate for CABG	IIa—CABG preferred over PCI	B	(123,138,148,164–165)
Viable ischemic myocardium that is perfused by coronary arteries that are not amenable to grafting	IIb—TMR as an adjunct to CABG	B	(203–207)
No anatomic or physiologic criteria for revascularization	III: Harm—CABG III: Harm—PCI	C	N/A

CABG, Coronary artery bypass graft; *CAD,* coronary artery disease; *COR,* class of recommendation; *FFR,* fractional flow reserve; *GDMT,* guideline-directed medical therapy; *LOE,* level of evidence; *N/A,* not applicable; *PCI,* percutaneous coronary intervention; *SYNTAX,* Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery; *TMR,* transmyocardial laser revascularization.

CAD), specific recommendations are made for patients with UA/NSTEMI or STEMI.

3.1. Heart Team Approach to Revascularization Decisions

Class I

1. **A Heart Team approach to revascularization is recommended in patients with unprotected left main or complex CAD.[105-107] *(Level of Evidence: C)***

Class IIa

1. **Calculation of the STS and SYNTAX (Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery) scores is reasonable in patients with unprotected left main and complex CAD.[107-114] *(Level of Evidence: B)***

3.2. Revascularization to Improve Survival

Left Main CAD Revascularization

Class I

1. **CABG to improve survival is recommended for patients with significant (≥50% diameter stenosis) left main coronary artery stenosis.[115-121] *(Level of Evidence: B)***

Class IIa

1. **PCI to improve survival is reasonable as an alternative to CABG in selected stable patients with significant (≥50% diameter stenosis) unprotected left main CAD with: (1) anatomic conditions associated with a low risk of PCI procedural complications and a high likelihood of good long-term outcome eg, a low SYNTAX score [≤22], ostial or trunk left main CAD); and (2) clinical characteristics that predict a significantly increased risk of adverse surgical outcomes (eg, STS-predicted risk of operative mortality ≥5%).[108,110,111,122-140,168] *(Level of Evidence: B)***
2. **PCI to improve survival is reasonable in patients with UA/NSTEMI when an unprotected left main coronary artery is the culprit lesion and the patient is not a candidate for CABG.[111,127,129-131,136,137,139,140,142] *(Level of Evidence: B)***
3. **PCI to improve survival is reasonable in patients with acute STEMI when an unprotected left main coronary artery is the culprit lesion, distal coronary flow is less than Thrombolysis In Myocardial Infarction grade 3, and PCI can be performed more rapidly and safely than CABG.[124,143,144] *(Level of Evidence: C)***

Class IIb

1. **PCI to improve survival may be reasonable as an alternative to CABG in selected stable patients with significant (≥50% diameter stenosis) unprotected left main CAD with: (1) anatomic conditions associated with a low to intermediate risk of PCI procedural complications and an intermediate to high likelihood of good long-term outcome (eg, low-intermediate SYNTAX score of <33, bifurcation left main CAD); and (2) clinical characteristics that predict an increased risk of adverse surgical outcomes (eg, moderate-severe chronic obstructive pulmonary disease, disability from previous stroke, or previous cardiac surgery; STS-predicted risk of operative mortality >2%).[108,110,111,122-140,145] *(Level of Evidence: B)***

Class III: Harm

1. **PCI to improve survival should not be performed in stable patients with significant (≥50% diameter stenosis) unprotected left main CAD who have unfavorable anatomy for PCI and who are good candidates for CABG.[108,110,111,115-123] *(Level of Evidence: B)***

Non-Left Main CAD Revascularization

Class I

1. **CABG to improve survival is beneficial in patients with significant (≥70% diameter) stenoses in 3 major coronary arteries (with or without involvement of the proximal LAD artery) or in the proximal LAD plus 1 other major coronary artery.[117,121,146-149] *(Level of Evidence: B)***
2. **CABG or PCI to improve survival is beneficial in survivors of sudden cardiac death with presumed ischemia-mediated ventricular tachycardia caused by significant (≥70% diameter) stenosis in a major coronary artery. *(CABG Level of Evidence: B;*[99,150,152] *PCI Level of Evidence: C*[150]*)***

Class IIa

1. CABG to improve survival is reasonable in patients with significant (≥70% diameter) stenoses in 2 major coronary arteries with severe or extensive myocardial ischemia (eg, high-risk criteria on stress testing, abnormal intracoronary hemodynamic evaluation, or >20% perfusion defect by myocardial perfusion stress imaging) or target vessels supplying a large area of viable myocardium.[153-156] *(Level of Evidence: B)*
2. CABG to improve survival is reasonable in patients with mild-moderate LV systolic dysfunction (ejection fraction 35% to 50%) and significant (≥70% diameter stenosis) multivessel CAD or proximal LAD coronary artery stenosis, when viable myocardium is present in the region of intended revascularization.[121,157-161] *(Level of Evidence: B)*
3. CABG with a LIMA graft to improve survival is reasonable in patients with significant (≥70% diameter) stenosis in the proximal LAD artery and evidence of extensive ischemia.[30,31,121,148] *(Level of Evidence: B)*
4. It is reasonable to choose CABG over PCI to improve survival in patients with complex 3-vessel CAD (eg, SYNTAX score >22), with or without involvement of the proximal LAD artery, who are good candidates for CABG.[123,138,148,164-165] *(Level of Evidence: B)*
5. CABG is probably recommended in preference to PCI to improve survival in patients with multivessel CAD and diabetes mellitus, particularly if a LIMA graft can be anastomosed to the LAD artery.[155,168-175] *(Level of Evidence: B)*

Class IIb

1. The usefulness of CABG to improve survival is uncertain in patients with significant (≥70%) stenoses in 2 major coronary arteries not involving the proximal LAD artery and without extensive ischemia.[148] *(Level of Evidence: C)*
2. The usefulness of PCI to improve survival is uncertain in patients with 2- or 3-vessel CAD (with or without involvement of the proximal LAD artery) or 1-vessel proximal LAD disease.[117,146,148,176] *(Level of Evidence: B)*
3. CABG might be considered with the primary or sole intent of improving survival in patients with SIHD with severe LV systolic dysfunction (ejection fraction <35%) whether or not viable myocardium is present.[121,157-161,177,178] *(Level of Evidence: B)*
4. The usefulness of CABG or PCI to improve survival is uncertain in patients with previous CABG and extensive anterior wall ischemia on noninvasive testing.[179-187] *(Level of Evidence: B)*

Class III: Harm

1. CABG or PCI should not be performed with the primary or sole intent to improve survival in patients with SIHD with 1 or more coronary stenoses that are not anatomically or functionally significant (eg, <70% diameter non-left main coronary artery stenosis, fractional flow reserve >0.80, no or only mild ischemia on noninvasive testing), involve only the left circumflex or right coronary artery, or subtend only a small area of viable myocardium.[121,146,153,154,188-192] *(Level of Evidence: B)*

3.3. Revascularization to Improve Symptoms

Class I

1. CABG or PCI to improve symptoms is beneficial in patients with 1 or more significant (≥70% diameter) coronary artery stenoses amenable to revascularization and unacceptable angina despite GDMT.[176,193-202] *(Level of Evidence: A)*

Class IIa

1. CABG or PCI to improve symptoms is reasonable in patients with 1 or more significant (≥70% diameter) coronary artery stenoses and unacceptable angina for whom GDMT cannot be implemented because of medication contraindications, adverse effects, or patient preferences. *(Level of Evidence: C)*
2. PCI to improve symptoms is reasonable in patients with previous CABG, 1 or more significant (≥70% diameter) coronary artery stenoses associated with ischemia, and unacceptable angina despite GDMT.[180,183,186] *(Level of Evidence: C)*
3. It is reasonable to choose CABG over PCI to improve symptoms in patients with complex 3-vessel CAD (eg, SYNTAX score >22), with or without involvement of the proximal LAD artery, who are good candidates for CABG.[123,138,148,164-165] *(Level of Evidence: B)*

Class IIb

1. CABG to improve symptoms might be reasonable for patients with previous CABG, 1 or more significant (≥70% diameter) coronary artery stenoses not amenable to PCI, and unacceptable angina despite GDMT.[187] *(Level of Evidence: C)*
2. Transmyocardial laser revascularization performed as an adjunct to CABG to improve symptoms may be reasonable in patients with viable ischemic myocardium that is perfused by arteries that are not amenable to grafting.[203-207] *(Level of Evidence: B)*

Class III: Harm

1. CABG or PCI to improve symptoms should not be performed in patients who do not meet anatomic (≥50% left main or ≥70% non-left main stenosis) or physiological (eg, abnormal fractional flow reserve) criteria for revascularization. *(Level of Evidence: C)*

3.4. Clinical Factors That May Influence the Choice of Revascularization

3.4.1. Dual Antiplatelet Therapy Compliance and Stent Thrombosis

Class III: Harm

1. PCI with coronary stenting (bare-metal stent or drug-eluting stent) should not be performed if the patient is not likely to be able to tolerate and comply with dual antiplatelet therapy for the appropriate duration of treatment based on the type of stent implanted.[208-211] *(Level of Evidence: B)*

3.5. Hybrid Coronary Revascularization

Class IIa

1. Hybrid coronary revascularization (defined as the planned combination of LIMA-to-LAD artery grafting and PCI of ≥1 non-LAD coronary arteries) is reasonable in patients with 1 or more of the following.[212-220] *(Level of Evidence: B)*:
   a. Limitations to traditional CABG, such as heavily calcified proximal aorta or poor target vessels for CABG (but amenable to PCI);
   b. Lack of suitable graft conduits;
   c. Unfavorable LAD artery for PCI (ie, excessive vessel tortuosity or chronic total occlusion).

Class IIb

1. **Hybrid coronary revascularization (defined as the planned combination of LIMA-to-LAD artery grafting and PCI of ≥1 non-LAD coronary arteries) may be reasonable as an alternative to multivessel PCI or CABG in an attempt to improve the overall risk-benefit ratio of the procedures.** ***(Level of Evidence: C)***

4. PERIOPERATIVE MANAGEMENT: RECOMMENDATIONS

4.1. Preoperative Antiplatelet Therapy

Class I

1. **Aspirin (100 mg to 325 mg daily) should be administered to CABG patients preoperatively.[221-223]** ***(Level of Evidence: B)***
2. **In patients referred for elective CABG, clopidogrel and ticagrelor should be discontinued for at least 5 days before surgery[224-226]** ***(Level of Evidence: B)*** **and prasugrel for at least 7 days** ***(Level of Evidence: C)*** **to limit blood transfusions.**
3. **In patients referred for urgent CABG, clopidogrel and ticagrelor should be discontinued for at least 24 hours to reduce major bleeding complications.[225,227-229]** ***(Level of Evidence: B)***
4. **In patients referred for CABG, short-acting intravenous glycoprotein IIb/IIIa inhibitors (eptifibatide or tirofiban) should be discontinued for at least 2 to 4 hours before surgery[230,231] and abciximab for at least 12 hours beforehand[232] to limit blood loss and transfusions.** ***(Level of Evidence: B)***

Class IIb

1. **In patients referred for urgent CABG, it may be reasonable to perform surgery less than 5 days after clopidogrel or ticagrelor has been discontinued and less than 7 days after prasugrel has been discontinued.** ***(Level of Evidence: C)***

4.2. Postoperative Antiplatelet Therapy

Class I

1. **If aspirin (100 mg to 325 mg daily) was not initiated preoperatively, it should be initiated within 6 hours postoperatively and then continued indefinitely to reduce the occurrence of saphenous vein graft closure and adverse cardiovascular events.[223,233,234]** ***(Level of Evidence: A)***

Class IIa

1. **For patients undergoing coronary artery bypass grafting, clopidogrel 75 mg daily is a reasonable alternative in patients who are intolerant of or allergic to aspirin.** ***(Level of Evidence: C)***

4.3. Management of Hyperlipidemia

Class I

1. **All patients undergoing CABG should receive statin therapy, unless contraindicated.[235-247,247a]** ***(Level of Evidence: A)***
2. **In patients undergoing CABG, an adequate dose of statin should be used to reduce low-density lipoprotein cholesterol to less than 100 mg/dL *and* to achieve at least a 30% lowering of low-density lipoprotein cholesterol.[235-239,247a]** ***(Level of Evidence: C)***

Class IIa

1. **In patients undergoing CABG, it is reasonable to treat with statin therapy to lower the low-density lipoprotein cholesterol to less than 70 mg/dL in very high-risk* patients.[236-238,247a,248-250]** ***(Level of Evidence: C)***
2. **For patients undergoing urgent or emergency CABG who are not taking a statin, it is reasonable to initiate high-dose statin therapy immediately.[250a]** ***(Level of Evidence: C)***

Class III: Harm

1. **Discontinuation of statin or other dyslipidemic therapy is not recommended before or after CABG in patients without adverse reactions to therapy.[251-253]** ***(Level of Evidence: B)***

4.4. Hormonal Manipulation

Class I

1. **Use of continuous intravenous insulin to achieve and maintain an early postoperative blood glucose concentration less than or equal to 180 mg/dL while avoiding hypoglycemia is indicated to reduce the incidence of adverse events, including deep sternal wound infection, after CABG.[254-256]** ***(Level of Evidence: B)***

Class IIb

1. **The use of continuous intravenous insulin designed to achieve a target intraoperative blood glucose concentration less than 140 mg/dL has uncertain effectiveness.[257-259]** ***(Level of Evidence: B)***

Class III: Harm

1. **Postmenopausal hormonal therapy (estrogen/prosgesterone) should not be administered to women undergoing CABG.[260-262]** ***(Level of Evidence: B)***

4.5. Perioperative Beta Blockers

Class I

1. **Beta blockers should be administered for at least 24 hours before CABG to all patients without contraindications to reduce the incidence or clinical sequelae of postoperative AF.[263-267,267a-267c]** ***(Level of Evidence: B)***
2. **Beta blockers should be reinstituted as soon as possible after CABG in all patients without contraindications to reduce the incidence or clinical sequelae of AF.[263-267,267a-267c]** ***(Level of Evidence: B)***
3. **Beta blockers should be prescribed to all CABG patients without contraindications at the time of hospital discharge.** ***(Level of Evidence: C)***

Class IIa

1. **Preoperative use of beta blockers in patients without contraindications, particularly in those with an LV ejection fraction (LVEF)**

* Presence of established cardiovascular disease plus (1) multiple major risk factors (especially diabetes), (2) severe and poorly controlled risk factors (especially continued cigarette smoking), (3) multiple risk factors of the metabolic syndrome (especially high triglycerides ≥200 mg/dL plus non-high-density lipoprotein cholesterol ≥130 mg/dL with low high-density lipoprotein cholesterol [<40 mg/dL]), and (4) acute coronary syndromes.

greater than 30%, can be effective in reducing the risk of in-hospital mortality.[268-270] *(Level of Evidence: B)*
2. Beta blockers can be effective in reducing the incidence of perioperative myocardial ischemia.[271-274] *(Level of Evidence: B)*
3. Intravenous administration of beta blockers in clinically stable patients unable to take oral medications is reasonable in the early postoperative period.[275] *(Level of Evidence: B)*

Class IIb

1. The effectiveness of preoperative beta blockers in reducing in-hospital mortality rate in patients with LVEF less than 30% is uncertain.[268,276] *(Level of Evidence: B)*

4.6. Angiotensin-Converting Enzyme Inhibitors and Angiotensin-Receptor Blockers

Class I

1. Angiotensin-converting enzyme (ACE) inhibitors and angiotensin-receptor blockers given before CABG should be reinstituted postoperatively once the patient is stable, unless contraindicated.[277-279] *(Level of Evidence: B)*
2. ACE inhibitors or angiotensin-receptor blockers should be initiated postoperatively and continued indefinitely in CABG patients who were not receiving them preoperatively, who are stable, and who have an LVEF less than or equal to 40%, hypertension, diabetes mellitus, or chronic kidney disease, unless contraindicated.[278,279a,279b] *(Level of Evidence: A)*

Class IIa

1. It is reasonable to initiate ACE inhibitors or angiotensin-receptor blockers postoperatively and to continue them indefinitely in all CABG patients who were not receiving them preoperatively and are considered to be at low risk (ie, those with a normal LVEF in whom cardiovascular risk factors are well controlled), unless contraindicated.[278-282] *(Level of Evidence: B)*

Class IIb

1. The safety of the preoperative administration of ACE inhibitors or angiotensin-receptor blockers in patients on chronic therapy is uncertain.[283-288] *(Level of Evidence: B)*
2. The safety of initiating ACE inhibitors or angiotensin-receptor blockers before hospital discharge is not well established.[278,280,282,289] *(Level of Evidence: B)*

4.7. Smoking Cessation

Class I

1. All smokers should receive in-hospital educational counseling and be offered smoking cessation therapy during CABG hospitalization.[291-293,293a] *(Level of Evidence: A)*

Class IIb

1. The effectiveness of pharmacological therapy for smoking cessation offered to patients before hospital discharge is uncertain. *(Level of Evidence: C)*

4.8. Emotional Dysfunction and Psychosocial Considerations

Class IIa

1. Cognitive behavior therapy or collaborative care for patients with clinical depression after CABG can be beneficial to reduce objective measures of depression.[294-298] *(Level of Evidence: B)*

4.9. Cardiac Rehabilitation

Class I

1. Cardiac rehabilitation is recommended for all eligible patients after CABG.[299-301,301a-301d] *(Level of Evidence: A)*

4.10. Perioperative Monitoring

4.10.1. Electrocardiographic Monitoring

Class I

1. Continuous monitoring of the electrocardiogram for arrhythmias should be performed for at least 48 hours in all patients after CABG.[265,302,303] *(Level of Evidence: B)*

Class IIa

1. Continuous ST-segment monitoring for detection of ischemia is reasonable in the intraoperative period for patients undergoing CABG.[56,304-306] *(Level of Evidence: B)*

Class IIb

1. Continuous ST-segment monitoring for detection of ischemia may be considered in the early postoperative period after CABG.[272,302,307-310] *(Level of Evidence: B)*

4.10.2. Pulmonary Artery Catheterization

Class I

1. Placement of a pulmonary artery catheter is indicated, preferably before the induction of anesthesia or surgical incision, in patients in cardiogenic shock undergoing CABG. *(Level of Evidence: C)*

Class IIa

1. Placement of a pulmonary artery catheter can be useful in the intraoperative or early postoperative period in patients with acute hemodynamic instability.[311-316] *(Level of Evidence: B)*

Class IIb

1. Placement of a pulmonary artery catheter may be reasonable in clinically stable patients undergoing CABG after consideration of baseline patient risk, the planned surgical procedure, and the practice setting.[311-316] *(Level of Evidence: B)*

4.10.3. Central Nervous System Monitoring

Class IIb

1. The effectiveness of intraoperative monitoring of the processed electroencephalogram to reduce the possibility of adverse recall of

clinical events or for detection of cerebral hypoperfusion in CABG patients is uncertain.[449-451] *(Level of Evidence: B)*
2. The effectiveness of routine use of intraoperative or early postoperative monitoring of cerebral oxygen saturation via near-infrared spectroscopy to detect cerebral hypoperfusion in patients undergoing CABG is uncertain.[317-319] *(Level of Evidence: B)*

5. CABG-ASSOCIATED MORBIDITY AND MORTALITY: OCCURRENCE AND PREVENTION: RECOMMENDATIONS

5.1. Public Reporting of Cardiac Surgery Outcomes

Class I

1. Public reporting of cardiac surgery outcomes should use risk-adjusted results based on clinical data.[320-327] *(Level of Evidence: B)*

5.1.1. Use of Outcomes or Volume as CABG Quality Measures

Class I

1. All cardiac surgery programs should participate in a state, regional, or national clinical data registry and should receive periodic reports of their risk-adjusted outcomes. *(Level of Evidence: C)*

Class IIa

1. When credible risk-adjusted outcomes data are not available, volume can be useful as a structural metric of CABG quality.[328-342] *(Level of Evidence: B)*

Class IIb

1. Affiliation with a high-volume tertiary center might be considered by cardiac surgery programs that perform fewer than 125 CABG procedures annually. *(Level of Evidence: C)*

5.2. Use of Epiaortic Ultrasound Imaging to Reduce Stroke Rates

Class IIa

1. Routine epiaortic ultrasound scanning is reasonable to evaluate the presence, location, and severity of plaque in the ascending aorta to reduce the incidence of atheroembolic complications.[343-345] *(Level of Evidence: B)*

5.3. The Role of Preoperative Carotid Artery Noninvasive Screening in CABG Patients

Class I

1. A multidisciplinary team approach (consisting of a cardiologist, cardiac surgeon, vascular surgeon, and neurologist) is recommended for patients with clinically significant carotid artery disease for whom CABG is planned. *(Level of Evidence: C)*

Class IIa

1. Carotid artery duplex scanning is reasonable in selected patients who are considered to have high-risk features (ie, age >65 years, left main coronary stenosis, peripheral artery disease, history of cerebrovascular disease [transient ischemic attack, stroke, etc.], hypertension, smoking, and diabetes mellitus).[346,347] *(Level of Evidence: C)*
2. In the CABG patient with a previous transient ischemic attack or stroke and a significant (50% to 99%) carotid artery stenosis, it is reasonable to consider carotid revascularization in conjunction with CABG. In such an individual, the sequence and timing (simultaneous or staged) of carotid intervention and CABG should be determined by the patient's relative magnitudes of cerebral and myocardial dysfunction. *(Level of Evidence: C)*

Class IIb

1. In the patient scheduled to undergo CABG who has no history of transient ischemic attack or stroke, carotid revascularization may be considered in the presence of bilateral severe (70% to 99%) carotid stenoses or a unilateral severe carotid stenosis with a contralateral occlusion. *(Level of Evidence: C)*

5.4. Mediastinitis/Perioperative Infection

Class I

1. Preoperative antibiotics should be administered to all patients to reduce the risk of postoperative infection.[348-353] *(Level of Evidence: A)*
2. A first- or second-generation cephalosporin is recommended for prophylaxis in patients without methicillin-resistant *Staphylococcus aureus* colonization.[353-361] *(Level of Evidence: A)*
3. Vancomycin alone or in combination with other antibiotics to achieve broader coverage is recommended for prophylaxis in patients with proven or suspected methicillin-resistant *S. aureus* colonization.[356,362-364] *(Level of Evidence: B)*
4. A deep sternal wound infection should be treated with aggressive surgical debridement in the absence of complicating circumstances. Primary or secondary closure with muscle or omental flap is recommended.[365-367] Vacuum therapy in conjunction with early and aggressive debridement is an effective adjunctive therapy.[368-377] *(Level of Evidence: B)*
5. Use of a continuous intravenous insulin protocol to achieve and maintain an early postoperative blood glucose concentration less than or equal to 180 mg/dL while avoiding hypoglycemia is indicated to reduce the risk of deep sternal wound infection.[256,259,378-381] *(Level of Evidence: B)*

Class IIa

1. When blood transfusions are needed, leukocyte-filtered blood can be useful to reduce the rate of overall perioperative infection and in-hospital death.[382-385] *(Level of Evidence: B)*
2. The use of intranasal mupirocin is reasonable in nasal carriers of *S. aureus*.[386,387] *(Level of Evidence: A)*
3. The routine use of intranasal mupirocin is reasonable in patients who are not carriers of *S. aureus,* unless an allergy exists. *(Level of Evidence: C)*

Class IIb

1. The use of bilateral internal mammary arteries in patients with diabetes mellitus is associated with an increased risk of deep sternal wound infection, but it may be reasonable when the overall benefit to the patient outweighs this increased risk. *(Level of Evidence: C)*

5.5. Renal Dysfunction

Class IIb

1. In patients with preoperative renal dysfunction (creatinine clearance <60 mL/min), off-pump CABG may be reasonable to reduce the risk of acute kidney injury.[388-392] *(Level of Evidence: B)*
2. In patients with preexisting renal dysfunction undergoing on-pump CABG, maintenance of a perioperative hematocrit greater than 19% and mean arterial pressure greater than 60 mm Hg may be reasonable. *(Level of Evidence: C)*
3. In patients with preexisting renal dysfunction, a delay of surgery after coronary angiography may be reasonable until the effect of radiographic contrast material on renal function is assessed.[393-395] *(Level of Evidence: B)*
4. The effectiveness of pharmacological agents to provide renal protection during cardiac surgery is uncertain.[396-418] *(Level of Evidence: B)*

5.6. Perioperative Myocardial Dysfunction

Class IIa

1. In the absence of severe, symptomatic aorto-iliac occlusive disease or peripheral artery disease, the insertion of an intra-aortic balloon is reasonable to reduce mortality rate in CABG patients who are considered to be at high risk (eg, those who are undergoing reoperation or have LVEF <30% or left main CAD).[419-424] *(Level of Evidence: B)*
2. Measurement of biomarkers of myonecrosis (eg, creatine kinase-MB, troponin) is reasonable in the first 24 hours after CABG.[425] *(Level of Evidence: B)*

5.6.1. Transfusion

Class I

1. Aggressive attempts at blood conservation are indicated to limit hemodilutional anemia and the need for intraoperative and perioperative allogeneic red blood cell transfusion in CABG patients.[426-429] *(Level of Evidence: B)*

5.7. Perioperative Dysrhythmias

Class I

1. Beta blockers should be administered for at least 24 hours before CABG to all patients without contraindications to reduce the incidence or clinical sequelae of postoperative AF.[263-267,267a-267c] *(Level of Evidence: B)*
2. Beta blockers should be reinstituted as soon as possible after CABG in all patients without contraindications to reduce the incidence or clinical sequelae of AF.[263-267,267a-267c] *(Level of Evidence: B)*

Class IIa

1. Preoperative administration of amiodarone to reduce the incidence of postoperative AF is reasonable for patients at high risk for postoperative AF who have contraindications to beta blockers.[430] *(Level of Evidence: B)*
2. Digoxin and nondihydropyridine calcium channel blockers can be useful to control the ventricular rate in the setting of AF but are not indicated for prophylaxis.[265] *(Level of Evidence: B)*

5.8. Perioperative Bleeding/Transfusion

Class I

1. Lysine analogues are useful intraoperatively and postoperatively in patients undergoing on-pump CABG to reduce perioperative blood loss and transfusion requirements.[431-438] *(Level of Evidence: A)*
2. A multimodal approach with transfusion algorithms, point-of-care testing, and a focused blood conservation strategy should be used to limit the number of transfusions.[439-444] *(Level of Evidence: A)*
3. In patients taking thienopyridines (clopidogrel or prasugrel) or ticagrelor in whom elective CABG is planned, clopidogrel and ticagrelor should be withheld for at least 5 days[224,225,227,228,445-451] *(Level of Evidence: B)* and prasugrel for at least 7 days [452] *(Level of Evidence: C)* before surgery.
4. It is recommended that surgery be delayed after the administration of streptokinase, urokinase, and tissue-type plasminogen activators until hemostatic capacity is restored, if possible. The timing of recommended delay should be guided by the pharmacodynamic half-life of the involved agent. *(Level of Evidence: C)*
5. Tirofiban or eptifibatide should be discontinued at least 2 to 4 hours before CABG and abciximab at least 12 hours before CABG.[230-232,436,437,453-457] *(Level of Evidence: B)*

Class IIa

1. It is reasonable to consider off-pump CABG to reduce perioperative bleeding and allogeneic blood transfusion.[458-464] *(Level of Evidence: A)*

6. SPECIFIC PATIENT SUBSETS: RECOMMENDATIONS

6.1. Anomalous Coronary Arteries

Class I

1. Coronary revascularization should be performed in patients with:
   a. A left main coronary artery that arises anomalously and then courses between the aorta and pulmonary artery.[465-467] *(Level of Evidence: B)*
   b. A right coronary artery that arises anomalously and then courses between the aorta and pulmonary artery with evidence of myocardial ischemia.[465-468] *(Level of Evidence: B)*

Class IIb

1. Coronary revascularization may be reasonable in patients with a LAD coronary artery that arises anomalously and then courses between the aorta and pulmonary artery. *(Level of Evidence: C)*

6.2. Patients With Chronic Obstructive Pulmonary Disease/Respiratory Insufficiency

Class IIa

1. Preoperative intensive inspiratory muscle training is reasonable to reduce the incidence of pulmonary complications in patients at high risk for respiratory complications after CABG.[469] *(Level of Evidence: B)*

Class IIb

1. **After CABG, noninvasive positive pressure ventilation may be reasonable to improve pulmonary mechanics and to reduce the need for reintubation.[470,471] *(Level of Evidence: B)***
2. **High thoracic epidural analgesia may be considered to improve lung function after CABG.[472,473] *(Level of Evidence: B***

6.3. Patients With End-Stage Renal Disease on Dialysis

Class IIb

1. **CABG to improve survival rate may be reasonable in patients with end-stage renal disease undergoing CABG for left main coronary artery stenosis of greater than or equal to 50%.[474] *(Level of Evidence: C)***
2. **CABG to improve survival rate or to relieve angina despite GDMT may be reasonable for patients with end-stage renal disease with significant stenoses (≥70%) in 3 major vessels or in the proximal LAD artery plus 1 other major vessel, regardless of LV systolic function.[475] *(Level of Evidence: B)***

Class III: Harm

1. **CABG should not be performed in patients with end-stage renal disease whose life expectancy is limited by noncardiac issues. *(Level of Evidence: C)***

6.4. Patients With Concomitant Valvular Disease

Class I

1. **Patients undergoing CABG who have at least moderate aortic stenosis should have concomitant aortic valve replacement.[476-479] *(Level of Evidence: B)***
2. **Patients undergoing CABG who have severe ischemic mitral valve regurgitation not likely to resolve with revascularization should have concomitant mitral valve repair or replacement at the time of CABG.[480-485] *(Level of Evidence: B)***

Class IIa

1. **In patients undergoing CABG who have moderate ischemic mitral valve regurgitation not likely to resolve with revascularization, concomitant mitral valve repair or replacement at the time of CABG is reasonable.[480-485] *(Level of Evidence: B)***

Class IIb

1. **Patients undergoing CABG who have mild aortic stenosis may be considered for concomitant aortic valve replacement when evidence (eg, moderate-severe leaflet calcification) suggests that progression of the aortic stenosis may be rapid and the risk of the combined procedure is acceptable. *(Level of Evidence: C)***

6.5. Patients With Previous Cardiac Surgery

Class IIa

1. **In patients with a patent LIMA to the LAD artery and ischemia in the distribution of the right or left circumflex coronary arteries, it is reasonable to recommend reoperative CABG to treat angina if GDMT has failed and the coronary stenoses are not amenable to PCI.[186,486] *(Level of Evidence: B)***

STAFF

References

1. ACCF/AHA Task Force on Practice Guidelines. Methodologies and Policies from the ACCF/AHA Task Force on Practice Guidelines. Available at; http://assets.cardiosource.com/Methodology_Manual_for_ACC_AHA_Writing_Committees.pdf. http://circ.ahajournals.org/site/manual/index.xhtml. Accessed July 1, 2011.
2. Institute of Medicine. Finding What Works in Health Care: Standards for Systematic Reviews. Washington, DC: The National Academies Press; 2011.
3. Institute of Medicine. Clinical Practice Guidelines We Can Trust. Washington, DC: The National Academies Press; 2011.
4. Hillis LD, Smith PK, Anderson JL, et al. 2011 ACCF/AHA guideline for coronary artery bypass graft surgery: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2011. published online before print November 7, 2011, doi:10.1016/j.jacc.2011.08.009. Accessed November 7, 2011.
5. Hawkes CA, Dhileepan S, Foxcroft D. Early extubation for adult cardiac surgical patients. Cochrane Database Syst Rev. 2003;CD003587-10.1002/14651858.CD003587.
6. Myles PS, Daly DJ, Djaiani G, et al. A systematic review of the safety and effectiveness of fast-track cardiac anesthesia. *Anesthesiology*. 2003;99:982-7.
7. van Mastrigt GA, Maessen JG, Heijmans J, et al. Does fast-track treatment lead to a decrease of intensive care unit and hospital length of stay in coronary artery bypass patients? A meta-regression of randomized clinical trials. *Crit Care Med*. 2006;34:1624-34.

8. Bainbridge D, Martin JE, Cheng DC. Patient-controlled versus nurse-controlled analgesia after cardiac surgery—a meta-analysis. *Can J Anaesth*. 2006;53: 492-9.
9. Brennan F, Carr DB, Cousins M. Pain management: a fundamental human right. *Anesth Analg*. 2007;105:205-21.
10. Lahtinen P, Kokki H, Hynynen M. Pain after cardiac surgery: a prospective cohort study of 1-year incidence and intensity. *Anesthesiology.* 2006;105: 794-800.
11. Serfontein L. Awareness in cardiac anesthesia. *Curr Opin Anaesthesiol*. 2010; 23:103-8.
12. Taillefer M-C, Carrier M, Belisle S, et al. Prevalence, characteristics, and predictors of chronic nonanginal postoperative pain after a cardiac operation: a cross-sectional study. *J Thorac Cardiovasc Surg*. 2006;131:1274-80.
13. Martinez EA, Marsteller JA, Thompson DA, et al. The Society of Cardiovascular Anesthesiologists' FOCUS initiative: Locating Errors through Networked Surveillance (LENS) project vision. *Anesth Analg*. 2010;110:307-11.
14. Wadhera RK, Parker SH, Burkhart HM, et al. Is the ''sterile cockpit'' concept applicable to cardiovascular surgery critical intervals or critical events? The impact of protocol-driven communication during cardiopulmonary bypass. *J Thorac Cardiovasc Surg*. 2010;139:312-9.
15. Neily J, Mills PD, Young-Xu Y, et al. Association between implementation of a medical team training program and surgical mortality. *JAMA*. 2010;304: 1693-700.
16. Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med*. 2009;360:491-9.
17. Cahalan MK, Stewart W, Pearlman A, et al. American Society of Echocardiography and Society of Cardiovascular Anesthesiologists task force guidelines for training in perioperative echocardiography. *J Am Soc Echocardiogr.* 2002;15: 647-52.
18. Mathew JP, Glas K, Troianos CA, et al. American Society of Echocardiography/ Society of Cardiovascular Anesthesiologists recommendations and guidelines for continuous quality improvement in perioperative echocardiography. *J Am Soc Echocardiogr.* 2006;19:1303-13.
19. Thys DM. Cardiac anesthesia: thirty years later—the second annual Arthur E. Weyman lecture. *Anesth Analg*. 2009;109:1782-90.
20. Dowd NP, Cheng DC, Karski JM, et al. Intraoperative awareness in fast-track cardiac anesthesia. *Anesthesiology.* 1998;89:1068-73.
21. Groesdonk HV, Pietzner J, Borger MA, et al. The incidence of intraoperative awareness in cardiac surgery fast-track treatment. *J Cardiothorac Vasc Anesth*. 2010;24:785-9.
22. Cheng DC, Karski J, Peniston C, et al. Early tracheal extubation after coronary artery bypass graft surgery reduces costs and improves resource use: a prospective, randomized, controlled trial. *Anesthesiology.* 1996;85:1300-10.
23. Horlocker TT, Wedel DJ, Rowlingson JC, et al. Regional anesthesia in the patient receiving antithrombotic or thrombolytic therapy: American Society of Regional Anesthesia and Pain Medicine Evidence-Based Guidelines (Third Edition). *Reg Anesth Pain Med*. 2010;35:64-101.
24. Murphy GS, Szokol JW, Marymont JH, et al. Recovery of neuromuscular function after cardiac surgery: pancuronium versus rocuronium. *Anesth Analg*. 2003;96:1301-7.
25. Nygard E, Kofoed KF, Freiberg J, et al. Effects of high thoracic epidural analgesia on myocardial blood flow in patients with ischemic heart disease. *Circulation*. 2005;111:2165-70.
26. Tenenbein PK, Debrouwere R, Maguire D, et al. Thoracic epidural analgesia improves pulmonary function in patients undergoing cardiac surgery. *Can J Anaesth*. 2008;55:344-50.
27. Nussmeier NA, Whelton AA, Brown MT, et al. Complications of the COX-2 inhibitors parecoxib and valdecoxib after cardiac surgery. *N Engl J Med*. 2005;352:1081-91.
28. Ott E, Nussmeier NA, Duke PC, et al. Efficacy and safety of the cyclooxygenase 2 inhibitors parecoxib and valdecoxib in patients undergoing coronary artery bypass surgery. *J Thorac Cardiovasc Surg*. 2003;125:1481-92.
29. Boylan MJ, Lytle BW, Loop FD, et al. Surgical treatment of isolated left anterior descending coronary stenosis: comparison of left internal mammary artery and venous autograft at 18 to 20 years of follow-up. *J Thorac Cardiovasc Surg*. 1994;107:657-62.
30. Cameron A, Davis KB, Green G, et al. Coronary bypass surgery with internal-thoracic-artery grafts: effects on survival over a 15-year period. *N Engl J Med*. 1996;334:216-9.
31. Loop FD, Lytle BW, Cosgrove DM, et al. Influence of the internal-mammary-artery graft on 10-year survival and other cardiac events. *N Engl J Med.* 1986;314:1-6.
32. Sabik JFI, Lytle BW, Blackstone EH, et al. Comparison of saphenous vein and internal thoracic artery graft patency by coronary system. *Ann Thorac Surg*. 2005;79:544-51.
33. Lytle BW, Blackstone EH, Loop FD, et al. Two internal thoracic artery grafts are better than one. *J Thorac Cardiovasc Surg*. 1999;117:855-72.
34. Lytle BW, Blackstone EH, Sabik JF, et al. The effect of bilateral internal thoracic artery grafting on survival during 20 postoperative years. *Ann Thorac Surg*. 2004;78:2005-12.
35. Sabik JFI, Blackstone EH, Gillinov AM, et al. Influence of patient characteristics and arterial grafts on freedom from coronary reoperation. *J Thorac Cardiovasc Surg*. 2006;131:90-8.
36. Sabik JFI, Stockins A, Nowicki ER, et al. Does location of the second internal thoracic artery graft influence outcome of coronary artery bypass grafting? *Circulation*. 2008;118(Suppl):S210-5.
37. Stevens LM, Carrier M, Perrault LP, et al. Single versus bilateral internal thoracic artery grafts with concomitant saphenous vein grafts for multivessel coronary artery bypass grafting: effects on mortality and event-free survival. *J Thorac Cardiovasc Surg*. 2004;127:1408-15.
38. Sabik JFI, Lytle BW, Blackstone EH, et al. Does competitive flow reduce internal thoracic artery graft patency? *Ann Thorac Surg*. 2003;76:1490-6.
39. Acar C, Ramsheyi A, Pagny JY, et al. The radial artery for coronary artery bypass grafting: clinical and angiographic results at five years. *J Thorac Cardiovasc Surg*. 1998;116:981-9.
40. Maniar HS, Sundt TM, Barner HB, et al. Effect of target stenosis and location on radial artery graft patency. *J Thorac Cardiovasc Surg*. 2002;123:45-52.
41. Moran SV, Baeza R, Guarda E, et al. Predictors of radial artery patency for coronary bypass operations. *Ann Thorac Surg*. 2001;72:1552-6.
42. Possati G, Gaudino M, Alessandrini F, et al. Midterm clinical and angiographic results of radial artery grafts used for myocardial revascularization. *J Thorac Cardiovasc Surg*. 1998;116:1015-21.
43. Royse AG, Royse CF, Tatoulis J, et al. Postoperative radial artery angiography for coronary artery bypass surgery. *Eur J Cardiothorac Surg*. 2000;17:294-304.
44. Desai ND, Cohen EA, Naylor CD, et al. A randomized comparison of radial-artery and saphenous-vein coronary bypass grafts. *N Engl J Med*. 2004;351: 2302-9.
45. Eltzschig HK, Rosenberger P, Loffler M, et al. Impact of intraoperative transesophageal echocardiography on surgical decisions in 12,566 patients undergoing cardiac surgery. *Ann Thorac Surg*. 2008;85:845-52.
46. Savage RM, Lytle BW, Aronson S, et al. Intraoperative echocardiography is indicated in high-risk coronary artery bypass grafting. *Ann Thorac Surg*. 1997;64: 368-73.
47. Practice guidelines for perioperative transesophageal echocardiography: An updated report by the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists Task Force on Transesophageal Echocardiography. *Anesthesiology.* 2010;112:1084-96.
48. Bergquist BD, Bellows WH, Leung JM. Transesophageal echocardiography in myocardial revascularization: II: Influence on intraoperative decision making. *Anesth Analg*. 1996;82:1139-45.
49. Moises VA, Mesquita CB, Campos O, et al. Importance of intraoperative transesophageal echocardiography during coronary artery surgery without cardiopulmonary bypass. *J Am Soc Echocardiogr.* 1998;11:1139-44.
50. Qaddoura FE, Abel MD, Mecklenburg KL, et al. Role of intraoperative transesophageal echocardiography in patients having coronary artery bypass graft surgery. *Ann Thorac Surg*. 2004;78:1586-90.
51. Swaminathan M, Morris RW, De Meyts DD, et al. Deterioration of regional wall motion immediately after coronary artery bypass graft surgery is associated with long-term major adverse cardiac events. *Anesthesiology.* 2007;107:739-45.
52. Wang J, Filipovic M, Rudzitis A, et al. Transesophageal echocardiography for monitoring segmental wall motion during off-pump coronary artery bypass surgery. *Anesth Analg*. 2004;99:965-73.
53. Zimarino M, Gallina S, Di Fulvio M, et al. Intraoperative ischemia and long-term events after minimally invasive coronary surgery. *Ann Thorac Surg*. 2004;78:135-41.
54. Dyub AM, Whitlock RP, Abouzahr LL, et al. Preoperative intra-aortic balloon pump in patients undergoing coronary bypass surgery: a systematic review and meta-analysis. *J Card Surg*. 2008;23:79-86.
55. Heusch G. Heart rate in the pathophysiology of coronary blood flow and myocardial ischaemia: benefit from selective bradycardic agents. *Br J Pharmacol*. 2008;153:1589-601.
56. Slogoff S, Keats AS. Does perioperative myocardial ischemia lead to postoperative myocardial infarction? *Anesthesiology.* 1985;62:107-14.

57. Gibbons RJ, Balady GJ, Bricker JT, et al. ACC/AHA 2002 guideline update for exercise testing: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1997 Exercise Testing Guidelines) [published correction appears in J Am Coll Cardiol. 2006;48:1731]. *J Am Coll Cardiol*. 2002;40: 1531-40.
58. Lavana JD, Fraser JF, Smith SE, et al. Influence of timing of intraaortic balloon placement in cardiac surgical patients. *J Thorac Cardiovasc Surg*. 2010;140: 80-5.
59. Landoni G, Biondi-Zoccai GG, Zangrillo A, et al. Desflurane and sevoflurane in cardiac surgery: a meta-analysis of randomized clinical trials. *J Cardiothorac Vasc Anesth*. 2007;21:502-11.
60. Lucchinetti E, Hofer C, Bestmann L, et al. Gene regulatory control of myocardial energy metabolism predicts postoperative cardiac function in patients undergoing off-pump coronary artery bypass graft surgery: inhalational versus intravenous anesthetics. *Anesthesiology*. 2007;106:444-57.
61. Yao YT, Li LH. Sevoflurane versus propofol for myocardial protection in patients undergoing coronary artery bypass grafting surgery: a meta-analysis of randomized controlled trials. *Chin Med Sci J*. 2009;24:133-41.
62. Yu CH, Beattie WS. The effects of volatile anesthetics on cardiac ischemic complications and mortality in CABG: a meta-analysis. *Can J Anaesth*. 2006; 53:906-18.
63. Rabi D, Clement F, McAlister F, et al. Effect of perioperative glucose-insulin-potassium infusions on mortality and atrial fibrillation after coronary artery bypass grafting: a systematic review and meta-analysis. *Can J Cardiol*. 2010;26: 178-84.
64. Buckberg GD. Controlled reperfusion after ischemia may be the unifying recovery denominator. *J Thorac Cardiovasc Surg*. 2010;140:12-8.
65. Alexander JH, Emery R Jr, Carrier M, et al. Efficacy and safety of pyridoxal 5'-phosphate (MC-1) in high-risk patients undergoing coronary artery bypass graft surgery: the MEND-CABG II randomized clinical trial. *JAMA*. 2008; 299:1777-87.
66. Mangano DT. Effects of acadesine on myocardial infarction, stroke, and death following surgery: a meta-analysis of the 5 international randomized trials: the Multicenter Study of Perioperative Ischemia (McSPI) Research Group. *JAMA*. 1997;277:325-32.
67. Mangano DT, Miao Y, Tudor IC, et al. Post-reperfusion myocardial infarction: long-term survival improvement using adenosine regulation with acadesine. *J Am Coll Cardiol*. 2006;48:206-14.
68. Shernan SK, Fitch JC, Nussmeier NA, et al. Impact of pexelizumab, an anti-C5 complement antibody, on total mortality and adverse cardiovascular outcomes in cardiac surgical patients undergoing cardiopulmonary bypass. *Ann Thorac Surg*. 2004;77:942-9.
69. Smith PK, Shernan SK, Chen JC, et al. Effects of C5 complement inhibitor pexelizumab on outcome in high-risk coronary artery bypass grafting: Combined results from the PRIMO-CABG I and II trials. *J Thorac Cardiovasc Surg*. 2010;142:89-98.
70. Testa L, Van Gaal WJ, Bhindi R, et al. Pexelizumab in ischemic heart disease: a systematic review and meta-analysis on 15,196 patients. *J Thorac Cardiovasc Surg*. 2008;136:884-93.
71. Laurikka J, Wu ZK, Iisalo P, et al. Regional ischemic preconditioning enhances myocardial performance in off-pump coronary artery bypass grafting. *Chest*. 2002;121:1183-9.
72. Penttila HJ, Lepojarvi MV, Kaukoranta PK, et al. Ischemic preconditioning does not improve myocardial preservation during off-pump multivessel coronary operation. *Ann Thorac Surg*. 2003;75:1246-52.
73. Walsh SR, Tang TY, Kullar P, et al. Ischaemic preconditioning during cardiac surgery: systematic review and meta-analysis of perioperative outcomes in randomised clinical trials. *Eur J Cardiothorac Surg*. 2008;34:985-94.
74. Hausenloy DJ, Mwamure PK, Venugopal V, et al. Effect of remote ischaemic preconditioning on myocardial injury in patients undergoing coronary artery bypass graft surgery: a randomised controlled trial. *Lancet*. 2007;370:575-9.
75. Rahman IA, Mascaro JG, Steeds RP, et al. Remote ischemic preconditioning in human coronary artery bypass surgery: from promise to disappointment? *Circulation*. 2010;122(Suppl):S53-9.
76. Venugopal V, Hausenloy DJ, Ludman A, et al. Remote ischaemic preconditioning reduces myocardial injury in patients undergoing cardiac surgery with cold-blood cardioplegia: a randomised controlled trial. *Heart*. 2009; 95:1567-71.
77. Luo W, Li B, Chen R, et al. Effect of ischemic postconditioning in adult valve replacement. *Eur J Cardiothorac Surg*. 2008;33:203-8.
78. Ovize M, Baxter GF, Di Lisa F, et al. Postconditioning and protection from reperfusion injury: where do we stand? Position paper from the Working Group of Cellular Biology of the Heart of the European Society of Cardiology. *Cardiovasc Res*. 2010;87:406-23.
79. Alexiou K, Kappert U, Staroske A, et al. Coronary surgery for acute coronary syndrome: which determinants of outcome remain? *Clin Res Cardiol*. 2008;97: 601-8.
80. Chiu FC, Chang SN, Lin JW, et al. Coronary artery bypass graft surgery provides better survival in patients with acute coronary syndrome or ST-segment elevation myocardial infarction experiencing cardiogenic shock after percutaneous coronary intervention: a propensity score analysis. *J Thorac Cardiovasc Surg*. 2009;138:1326-30.
81. DeWood MA, Spores J, Berg R Jr, et al. Acute myocardial infarction: a decade of experience with surgical reperfusion in 701 patients. *Circulation*. 1983;68: II8-16.
82. Donatelli F, Benussi S, Triggiani M, et al. Surgical treatment for life-threatening acute myocardial infarction: a prospective protocol. *Eur J Cardiothorac Surg*. 1997;11:228-33.
83. Filizcan U, Kurc E, Cetemen S, et al. Mortality predictors in ST-elevated myocardial infarction patients undergoing coronary artery bypass grafting. *Angiology*. 2011;62:68-73.
84. Chevalier P, Burri H, Fahrat F, et al. Perioperative outcome and long-term survival of surgery for acute post-infarction mitral regurgitation. *Eur J Cardiothorac Surg*. 2004;26:330-5.
85. Lemery R, Smith HC, Giuliani ER, et al. Prognosis in rupture of the ventricular septum after acute myocardial infarction and role of early surgical intervention. *Am J Cardiol*. 1992;70:147-51.
86. Russo A, Suri RM, Grigioni F, et al. Clinical outcome after surgical correction of mitral regurgitation due to papillary muscle rupture. *Circulation*. 2008;118: 1528-34.
87. Shamshad F, Kenchaiah S, Finn PV, et al. Fatal myocardial rupture after acute myocardial infarction complicated by heart failure, left ventricular dysfunction, or both: the VALsartan In Acute myocardial iNfarcTion Trial (VALIANT). *Am Heart J*. 2010;160:145-51.
88. Tavakoli R, Weber A, Brunner-La Rocca H, et al. Results of surgery for irreversible moderate to severe mitral valve regurgitation secondary to myocardial infarction. *Eur J Cardiothorac Surg*. 2002;21:818-24.
89. Hochman JS, Sleeper LA, Webb JG, et al. Early revascularization in acute myocardial infarction complicated by cardiogenic shock: SHOCK Investigators: Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock. *N Engl J Med*. 1999;341:625-34.
90. Mehta RH, Lopes RD, Ballotta A, et al. Percutaneous coronary intervention or coronary artery bypass surgery for cardiogenic shock and multivessel coronary artery disease? *Am Heart J*. 2010;159:141-7.
91. White HD, Assmann SF, Sanborn TA, et al. Comparison of percutaneous coronary intervention and coronary artery bypass grafting after acute myocardial infarction complicated by cardiogenic shock: results from the Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock (SHOCK) trial. *Circulation*. 2005;112:1992-2001.
92. Ngaage DL, Cale AR, Cowen ME, et al. Early and late survival after surgical revascularization for ischemic ventricular fibrillation/tachycardia. *Ann Thorac Surg*. 2008;85:1278-81.
93. Parikh SV, de Lemos JA, Jessen ME, et al. Timing of in-hospital coronary artery bypass graft surgery for non-ST-segment elevation myocardial infarction patients results from the National Cardiovascular Data Registry ACTION Registry-GWTG (Acute Coronary Treatment and Intervention Outcomes Network Registry-Get With The Guidelines). *J Am Coll Cardiol Intv*. 2010;3: 419-27.
94. Lim HS, Farouque O, Andrianopoulos N, et al. Survival of elderly patients undergoing percutaneous coronary intervention for acute myocardial infarction complicated by cardiogenic shock. *J Am Coll Cardiol Intv*. 2009;2: 146-52.
95. Amin AP, Nathan S, Prodduturi P, et al. Survival benefit from early revascularization in elderly patients with cardiogenic shock after acute myocardial infarction: a cohort study. *J Invasive Cardiol*. 2009;21:305-12.
96. Migliorini A, Moschi G, Valenti R, et al. Routine percutaneous coronary intervention in elderly patients with cardiogenic shock complicating acute myocardial infarction. *Am Heart J*. 2006;152:903-8.
97. Hochman JS, Buller CE, Sleeper LA, et al. Cardiogenic shock complicating acute myocardial infarction-etiologies, management and outcome: a report from the SHOCK Trial Registry: SHould we emergently revascularize

Occluded Coronaries for cardiogenic shocK? *J Am Coll Cardiol*. 2000;36: 1063-70.
98. Dzavik V, Sleeper LA, Cocke TP, et al. Early revascularization is associated with improved survival in elderly patients with acute myocardial infarction complicated by cardiogenic shock: a report from the SHOCK Trial Registry. *Eur Heart J*. 2003;24:828-37.
99. Every NR, Fahrenbruch CE, Hallstrom AP, et al. Influence of coronary bypass surgery on subsequent outcome of patients resuscitated from out of hospital cardiac arrest. *J Am Coll Cardiol*. 1992;19:1435-9.
100. Kelly P, Ruskin JN, Vlahakes GJ, et al. Surgical coronary revascularization in survivors of prehospital cardiac arrest: its effect on inducible ventricular arrhythmias and long-term survival. *J Am Coll Cardiol*. 1990;15:267-73.
101. Barakate MS, Bannon PG, Hughes CF, et al. Emergency surgery after unsuccessful coronary angioplasty: a review of 15 years' experience. *Ann Thorac Surg*. 2003;75:1400-5.
102. Roy P, de Labriolle A, Hanna N, et al. Requirement for emergent coronary artery bypass surgery following percutaneous coronary intervention in the stent era. *Am J Cardiol*. 2009;103:950-3.
103. Craver JM, Weintraub WS, Jones EL, et al. Emergency coronary artery bypass surgery for failed percutaneous coronary angioplasty: a 10-year experience. *Ann Surg*. 1992;215:425-33.
104. Stamou SC, Hill PC, Haile E, et al. Clinical outcomes of nonelective coronary revascularization with and without cardiopulmonary bypass. *J Thorac Cardiovasc Surg*. 2006;131:28-33.
105. Feit F, Brooks MM, Sopko G, et al. Long-term clinical outcome in the Bypass Angioplasty Revascularization Investigation Registry: comparison with the randomized trial. *BARI Investigators. Circulation*. 2000;101:2795-802.
106. King SBI, Barnhart HX, Kosinski AS, et al. Angioplasty or surgery for multivessel coronary artery disease: comparison of eligible registry and randomized patients in the EAST trial and influence of treatment selection on outcomes: Emory Angioplasty versus Surgery Trial Investigators. *Am J Cardiol*. 1997; 79:1453-9.
107. Serruys PW, Morice MC, Kappetein AP, et al. Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease. *N Engl J Med*. 2009;360:961-72.
108. Chakravarty T, Buch MH, Naik H, et al. Predictive accuracy of SYNTAX score for predicting long-term outcomes of unprotected left main coronary artery revascularization. *Am J Cardiol*. 2011;107:360-6.
109. Grover FL, Shroyer AL, Hammermeister K, et al. A decade's experience with quality improvement in cardiac surgery using the Veterans Affairs and Society of Thoracic Surgeons national databases. *Ann Surg*. 2001;234:464-72.
110. Kim YH, Park DW, Kim WJ, et al. Validation of SYNTAX (Synergy between PCI with TAXUS and Cardiac Surgery) score for prediction of outcomes after unprotected left main coronary revascularization. *J Am Coll Cardiol Intv*. 2010; 3:612-23.
111. Morice MC, Serruys PW, Kappetein AP, et al. Outcomes in patients with de novo left main disease treated with either percutaneous coronary intervention using paclitaxel-eluting stents or coronary artery bypass graft treatment in the Synergy Between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery (SYNTAX) trial. *Circulation*. 2010;121: 2645-53.
112. Shahian DM, O'Brien SM, Filardo G, et al. The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 1—coronary artery bypass grafting surgery. *Ann Thorac Surg*. 2009;88 1 Suppl:S2-22.
113. Shahian DM, O'Brien SM, Normand SL, et al. Association of hospital coronary artery bypass volume with processes of care, mortality, morbidity, and the Society of Thoracic Surgeons composite quality score. *J Thorac Cardiovasc Surg*. 2010;139:273-82.
114. Welke KF, Peterson ED, Vaughan-Sarrazin MS, et al. Comparison of cardiac surgery volumes and mortality rates between the Society of Thoracic Surgeons and Medicare databases from 1993 through 2001. *Ann Thorac Surg*. 2007;84: 1538-46.
115. Caracciolo EA, Davis KB, Sopko G, et al. Comparison of surgical and medical group survival in patients with left main coronary artery disease: long-term CASS experience. *Circulation*. 1995;91:2325-34.
116. Chaitman BR, Fisher LD, Bourassa MG, et al. Effect of coronary bypass surgery on survival patterns in subsets of patients with left main coronary artery disease: report of the Collaborative Study in Coronary Artery Surgery (CASS). *Am J Cardiol*. 1981;48:765-77.
117. Dzavik V, Ghali WA, Norris C, et al. Long-term survival in 11,661 patients with multivessel coronary artery disease in the era of stenting: a report from the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) Investigators. *Am Heart J*. 2001;142:119-26.
118. Takaro T, Hultgren HN, Lipton MJ, et al. The VA cooperative randomized study of surgery for coronary arterial occlusive disease II: Subgroup with significant left main lesions. *Circulation*. 1976;54:III107-17.
119. Takaro T, Peduzzi P, Detre KM, et al. Survival in subgroups of patients with left main coronary artery disease: Veterans Administration Cooperative Study of Surgery for Coronary Arterial Occlusive Disease. *Circulation*. 1982;66: 14-22.
120. Taylor HA, Deumite NJ, Chaitman BR, et al. Asymptomatic left main coronary artery disease in the Coronary Artery Surgery Study (CASS) registry. *Circulation*. 1989;79:1171-9.
121. Yusuf S, Zucker D, Peduzzi P, et al. Effect of coronary artery bypass graft surgery on survival: overview of 10-year results from randomised trials by the Coronary Artery Bypass Graft Surgery Trialists Collaboration. *Lancet*. 1994;344: 563-70.
122. Capodanno D, Caggegi A, Miano M, et al. Global risk classification and clinical SYNTAX (Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery) score in patients undergoing percutaneous or surgical left main revascularization. *J Am Coll Cardiol Intv*. 2011;4:287-97.
123. Hannan EL, Wu C, Walford G, et al. Drug-eluting stents vs: coronary-artery bypass grafting in multivessel coronary disease. *N Engl J Med*. 2008;358:331-41.
124. Ellis SG, Tamai H, Nobuyoshi M, et al. Contemporary percutaneous treatment of unprotected left main coronary stenoses: initial results from a multicenter registry analysis 1994-1996. *Circulation*. 1997;96:3867-72.
125. Biondi-Zoccai GG, Lotrionte M, Moretti C, et al. A collaborative systematic review and meta-analysis on 1278 patients undergoing percutaneous drug-eluting stenting for unprotected left main coronary artery disease. *Am Heart J*. 2008; 155:274-83.
126. Boudriot E, Thiele H, Walther T, et al. Randomized comparison of percutaneous coronary intervention with sirolimus-eluting stents versus coronary artery bypass grafting in unprotected left main stem stenosis [published correction appears in J Am Coll Cardiol. 2011;57:1792]. *J Am Coll Cardiol*. 2011;57: 538-45.
127. Brener SJ, Galla JM, Bryant RI, et al. Comparison of percutaneous versus surgical revascularization of severe unprotected left main coronary stenosis in matched patients. *Am J Cardiol*. 2008;101:169-72.
128. Buszman PE, Kiesz SR, Bochenek A, et al. Acute and late outcomes of unprotected left main stenting in comparison with surgical revascularization. *J Am Coll Cardiol*. 2008;51:538-45.
129. Chieffo A, Morici N, Maisano F, et al. Percutaneous treatment with drug-eluting stent implantation versus bypass surgery for unprotected left main stenosis: a single-center experience. *Circulation*. 2006;113:2542-7.
130. Chieffo A, Magni V, Latib A, et al. 5-year outcomes following percutaneous coronary intervention with drug-eluting stent implantation versus coronary artery bypass graft for unprotected left main coronary artery lesions: the Milan experience. *J Am Coll Cardiol Intv*. 2010;3:595-601.
131. Lee MS, Kapoor N, Jamal F, et al. Comparison of coronary artery bypass surgery with percutaneous coronary intervention with drug-eluting stents for unprotected left main coronary artery disease. *J Am Coll Cardiol*. 2006;47: 864-70.
132. Makikallio TH, Niemela M, Kervinen K, et al. Coronary angioplasty in drug eluting stent era for the treatment of unprotected left main stenosis compared to coronary artery bypass grafting. *Ann Med*. 2008;40:437-43.
133. Naik H, White AJ, Chakravarty T, et al. A meta-analysis of 3,773 patients treated with percutaneous coronary intervention or surgery for unprotected left main coronary artery stenosis. *J Am Coll Cardiol Intv*. 2009;2:739-47.
134. Palmerini T, Marzocchi A, Marrozzini C, et al. Comparison between coronary angioplasty and coronary artery bypass surgery for the treatment of unprotected left main coronary artery stenosis (the Bologna Registry). *Am J Cardiol*. 2006; 98:54-9.
135. Park DW, Seung KB, Kim YH, et al. Long-term safety and efficacy of stenting versus coronary artery bypass grafting for unprotected left main coronary artery disease: 5-year results from the MAIN-COMPARE (Revascularization for Unprotected Left Main Coronary Artery Stenosis: Comparison of Percutaneous Coronary Angioplasty Versus Surgical Revascularization) registry. *J Am Coll Cardiol*. 2010;56:117-24.
136. Rodes-Cabau J, Deblois J, Bertrand OF, et al. Nonrandomized comparison of coronary artery bypass surgery and percutaneous coronary intervention for the treatment of unprotected left main coronary artery disease in octogenarians. *Circulation*. 2008;118:2374-81.

137. Sanmartin M, Baz JA, Claro R, et al. Comparison of drug-eluting stents versus surgery for unprotected left main coronary artery disease. *Am J Cardiol*. 2007; 100:970-3.
138. Kappetein AP, Mohr FW, Feldman TE, et al. Comparison of coronary bypass surgery with drug-eluting stenting for the treatment of left main and/or three-vessel disease: 3-year follow-up of the SYNTAX trial. *Eur Heart J*. 2011;17:2125-34.
139. Seung KB, Park DW, Kim YH, et al. Stents versus coronary-artery bypass grafting for left main coronary artery disease. *N Engl J Med*. 2008;358:1781-92.
140. White AJ, Kedia G, Mirocha JM, et al. Comparison of coronary artery bypass surgery and percutaneous drug-eluting stent implantation for treatment of left main coronary artery stenosis. *J Am Coll Cardiol Intv*. 2008;1:236-45.
141. Deleted in proof.
142. Montalescot G, Brieger D, Eagle KA, et al. Unprotected left main revascularization in patients with acute coronary syndromes. *Eur Heart J*. 2009;30: 2308-17.
143. Lee MS, Tseng CH, Barker CM, et al. Outcome after surgery and percutaneous intervention for cardiogenic shock and left main disease. *Ann Thorac Surg*. 2008;86:29-34.
144. Lee MS, Bokhoor P, Park SJ, et al. Unprotected left main coronary disease and ST-segment elevation myocardial infarction: a contemporary review and argument for percutaneous coronary intervention. *J Am Coll Cardiol Intv*. 2010;3: 791-5.
145. Park SJ, Kim YH, Park DW, et al. Randomized trial of stents versus bypass surgery for left main coronary artery disease. *N Engl J Med*. 2011;364:1718-27.
146. Jones RH, Kesler K, Phillips HR III, et al. Long-term survival benefits of coronary artery bypass grafting and percutaneous transluminal angioplasty in patients with coronary artery disease. *J Thorac Cardiovasc Surg*. 1996;111: 1013-25.
147. Myers WO, Schaff HV, Gersh BJ, et al. Improved survival of surgically treated patients with triple vessel coronary artery disease and severe angina pectoris: A report from the Coronary Artery Surgery Study (CASS) registry. *J Thorac Cardiovasc Surg*. 1989;97:487-95.
148. Smith PK, Califf RM, Tuttle RH, et al. Selection of surgical or percutaneous coronary intervention provides differential longevity benefit. *Ann Thorac Surg*. 2006;82:1420-8.
149. Varnauskas E. Twelve-year follow-up of survival in the randomized European Coronary Surgery Study. *N Engl J Med*. 1988;319:332-7.
150. Borger van der Burg AE, Bax JJ, Boersma E, et al. Impact of percutaneous coronary intervention or coronary artery bypass grafting on outcome after nonfatal cardiac arrest outside the hospital. *Am J Cardiol*. 2003;91:785-9.
151. Deleted in proof.
152. Kaiser GA, Ghahramani A, Bolooki H, et al. Role of coronary artery surgery in patients surviving unexpected cardiac arrest. *Surgery*. 1975;78:749-54.
153. Di Carli MF, Maddahi J, Rokhsar S, et al. Long-term survival of patients with coronary artery disease and left ventricular dysfunction: implications for the role of myocardial viability assessment in management decisions. *J Thorac Cardiovasc Surg*. 1998;116:997-1004.
154. Hachamovitch R, Hayes SW, Friedman JD, et al. Comparison of the short-term survival benefit associated with revascularization compared with medical therapy in patients with no prior coronary artery disease undergoing stress myocardial perfusion single photon emission computed tomography. *Circulation*. 2003;107:2900-7.
155. Sorajja P, Chareonthaitawee P, Rajagopalan N, et al. Improved survival in asymptomatic diabetic patients with high-risk SPECT imaging treated with coronary artery bypass grafting. *Circulation*. 2005;112:I311-6.
156. Davies RF, Goldberg AD, Forman S, et al. Asymptomatic Cardiac Ischemia Pilot (ACIP) study two-year follow-up: outcomes of patients randomized to initial strategies of medical therapy versus revascularization. *Circulation*. 1997;95: 2037-43.
157. Alderman EL, Fisher LD, Litwin P, et al. Results of coronary artery surgery in patients with poor left ventricular function (CASS). *Circulation*. 1983;68:785-95.
158. O'Connor CM, Velazquez EJ, Gardner LH, et al. Comparison of coronary artery bypass grafting versus medical therapy on long-term outcome in patients with ischemic cardiomyopathy (a 25-year experience from the Duke Cardiovascular Disease Databank). *Am J Cardiol*. 2002;90:101-7.
159. Phillips HR, O'Connor CM, Rogers J. Revascularization for heart failure. *Am Heart J*. 2007;153:65-73.
160. Tarakji KG, Brunken R, McCarthy PM, et al. Myocardial viability testing and the effect of early intervention in patients with advanced left ventricular systolic dysfunction. *Circulation*. 2006;113:230-7.
161. Tsuyuki RT, Shrive FM, Galbraith PD, et al. Revascularization in patients with heart failure. *CMAJ*. 2006;175:361-5.
162. Deleted in proof.
163. Deleted in proof.
164. Brener SJ, Lytle BW, Casserly IP, et al. Propensity analysis of long-term survival after surgical or percutaneous revascularization in patients with multivessel coronary artery disease and high-risk features. *Circulation*. 2004;109:2290-5.
165. Hannan EL, Racz MJ, Walford G, et al. Long-term outcomes of coronary-artery bypass grafting versus stent implantation. *N Engl J Med*. 2005;352:2174-83.
166. Deleted in proof.
167. Deleted in proof.
168. The BARI Investigators. Influence of diabetes on 5-year mortality and morbidity in a randomized trial comparing CABG and PTCA in patients with multivessel disease: the Bypass Angioplasty Revascularization Investigation (BARI). *Circulation*. 1997;96:1761-9.
169. The BARI Investigators. The final 10-year follow-up results from the BARI randomized trial. *J Am Coll Cardiol*. 2007;49:1600-6.
170. Banning AP, Westaby S, Morice MC, et al. Diabetic and nondiabetic patients with left main and/or 3-vessel coronary artery disease: comparison of outcomes with cardiac surgery and paclitaxel-eluting stents. *J Am Coll Cardiol*. 2010;55: 1067-75.
171. Hoffman SN, TenBrook JA, Wolf MP, et al. A meta-analysis of randomized controlled trials comparing coronary artery bypass graft with percutaneous transluminal coronary angioplasty: one- to eight-year outcomes. *J Am Coll Cardiol*. 2003;41:1293-304.
172. Hueb W, Lopes NH, Gersh BJ, et al. Five-year follow-up of the Medicine, Angioplasty, or Surgery Study (MASS II): a randomized controlled clinical trial of 3 therapeutic strategies for multivessel coronary artery disease. *Circulation*. 2007;115:1082-9.
173. Malenka DJ, Leavitt BJ, Hearne MJ, et al. Comparing long-term survival of patients with multivessel coronary disease after CABG or PCI: analysis of BARI-like patients in northern New England. *Circulation*. 2005;112:I371-6.
174. Niles NW, McGrath PD, Malenka D, et al. Survival of patients with diabetes and multivessel coronary artery disease after surgical or percutaneous coronary revascularization: results of a large regional prospective study. *Northern New England Cardiovascular Disease Study Group. J Am Coll Cardiol*. 2001;37: 1008-15.
175. Weintraub WS, Stein B, Kosinski A, et al. Outcome of coronary bypass surgery versus coronary angioplasty in diabetic patients with multivessel coronary artery disease. *J Am Coll Cardiol*. 1998;31:10-9.
176. Boden WE, O'Rourke RA, Teo KK, et al. Optimal medical therapy with or without PCI for stable coronary disease. *N Engl J Med*. 2007;356:1503-16.
177. Bonow RO, Maurer G, Lee KL, et al. Myocardial viability and survival in ischemic left ventricular dysfunction. *N Engl J Med*. 2011;364:1617-25.
178. Velazquez EJ, Lee KL, Deja MA, et al. Coronary-Artery Bypass Surgery in Patients with Left Ventricular Dysfunction. *N Engl J Med*. 2011;364:1607-16.
179. Brener SJ, Lytle BW, Casserly IP, et al. Predictors of revascularization method and long-term outcome of percutaneous coronary intervention or repeat coronary bypass surgery in patients with multivessel coronary disease and previous coronary bypass surgery. *Eur Heart J*. 2006;27:413-8.
180. Gurfinkel EP, Perez dlH, Brito VM, et al. Invasive vs non-invasive treatment in acute coronary syndromes and prior bypass surgery. *Int J Cardiol*. 2007;119: 65-72.
181. Lytle BW, Loop FD, Taylor PC, et al. The effect of coronary reoperation on the survival of patients with stenoses in saphenous vein bypass grafts to coronary arteries. *J Thorac Cardiovasc Surg*. 1993;105:605-12.
182. Morrison DA, Sethi G, Sacks J, et al. Percutaneous coronary intervention versus coronary artery bypass graft surgery for patients with medically refractory myocardial ischemia and risk factors for adverse outcomes with bypass: a multicenter, randomized trial: Investigators of the Department of Veterans Affairs Cooperative Study #385, the Angina With Extremely Serious Operative Mortality Evaluation (AWESOME). *J Am Coll Cardiol*. 2001;38:143-9.
183. Pfautsch P, Frantz E, Ellmer A, et al. [Long-term outcome of therapy of recurrent myocardial ischemia after surgical revascularization]. *Z Kardiol*. 1999;88: 489-97.
184. Sergeant P, Blackstone E, Meyns B, et al. First cardiological or cardiosurgical reintervention for ischemic heart disease after primary coronary artery bypass grafting. *Eur J Cardiothorac Surg*. 1998;14:480-7.
185. Stephan WJ, O'Keefe JH Jr, Piehler JM, et al. Coronary angioplasty versus repeat coronary artery bypass grafting for patients with previous bypass surgery. *J Am Coll Cardiol*. 1996;28:1140-6.

186. Subramanian S, Sabik JF III, Houghtaling PL, et al. Decision-making for patients with patent left internal thoracic artery grafts to left anterior descending. *Ann Thorac Surg*. 2009;87:1392-8.
187. Weintraub WS, Jones EL, Morris DC, et al. Outcome of reoperative coronary bypass surgery versus coronary angioplasty after previous bypass surgery. *Circulation*. 1997;95:868-77.
188. Shaw LJ, Berman DS, Maron DJ, et al. Optimal medical therapy with or without percutaneous coronary intervention to reduce ischemic burden: results from the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) trial nuclear substudy. *Circulation*. 2008; 117:1283-91.
189. Cashin WL, Sanmarco ME, Nessim SA, et al. Accelerated progression of atherosclerosis in coronary vessels with minimal lesions that are bypassed. *N Engl J Med*. 1984;311:824-8.
190. Pijls NH, De Bruyne B, Peels K, et al. Measurement of fractional flow reserve to assess the functional severity of coronary-artery stenoses. *N Engl J Med*. 1996; 334:1703-8.
191. Tonino PA, De Bruyne B, Pijls NH, et al. Fractional flow reserve versus angiography for guiding percutaneous coronary intervention. *N Engl J Med*. 2009;360: 213-24.
192. Sawada S, Bapat A, Vaz D, et al. Incremental value of myocardial viability for prediction of long-term prognosis in surgically revascularized patients with left ventricular dysfunction. *J Am Coll Cardiol*. 2003;42:2099-105.
193. TIME Investigators. Trial of invasive versus medical therapy in elderly patients with chronic symptomatic coronary-artery disease (TIME); a randomised trial. *Lancet*. 2001;358:951-7.
194. Benzer W, Hofer S, Oldridge NB. Health-related quality of life in patients with coronary artery disease after different treatments for angina in routine clinical practice. *Herz*. 2003;28:421-8.
195. Bonaros N, Schachner T, Ohlinger A, et al. Assessment of health-related quality of life after coronary revascularization. *Heart Surg Forum*. 2005;8:E380-5.
196. Bucher HC, Hengstler P, Schindler C, et al. Percutaneous transluminal coronary angioplasty versus medical treatment for non-acute coronary heart disease: meta-analysis of randomised controlled trials. *BMJ*. 2000;321:73-7.
197. Favarato ME, Hueb W, Boden WE, et al. Quality of life in patients with symptomatic multivessel coronary artery disease: a comparative post hoc analyses of medical, angioplasty or surgical strategies-MASS II trial. *Int J Cardiol*. 2007; 116:364-70.
198. Hueb W, Lopes N, Gersh BJ, et al. Ten-year follow-up survival of the Medicine, Angioplasty, or Surgery Study (MASS II): a randomized controlled clinical trial of 3 therapeutic strategies for multivessel coronary artery disease. *Circulation*. 2010;122:949-57.
199. Pocock SJ, Henderson RA, Seed P, et al. Quality of life, employment status, and anginal symptoms after coronary angioplasty or bypass surgery: 3-year follow-up in the Randomized Intervention Treatment of Angina (RITA) Trial. *Circulation*. 1996;94:135-42.
200. Pocock SJ, Henderson RA, Clayton T, et al. Quality of life after coronary angioplasty or continued medical treatment for angina: three-year follow-up in the RITA-2 trial: Randomized Intervention Treatment of Angina. *J Am Coll Cardiol*. 2000;35:907-14.
201. Weintraub WS, Spertus JA, Kolm P, et al. Effect of PCI on quality of life in patients with stable coronary disease. *N Engl J Med*. 2008;359:677-87.
202. Wijeysundera HC, Nallamothu BK, Krumholz HM, et al. Meta-analysis: effects of percutaneous coronary intervention versus medical therapy on angina relief. *Ann Intern Med*. 2010;152:370-9.
203. Schofield PM, Sharples LD, Caine N, et al. Transmyocardial laser revascularisation in patients with refractory angina: a randomised controlled trial [published correction appears in Lancet. 1999;353:1714]. *Lancet*. 1999;353:519-24.
204. Aaberge L, Nordstrand K, Dragsund M, et al. Transmyocardial revascularization with CO2 laser in patients with refractory angina pectoris: Clinical results from the Norwegian randomized trial. *J Am Coll Cardiol*. 2000;35: 1170-7.
205. Burkhoff D, Schmidt S, Schulman SP, et al. Transmyocardial laser revascularisation compared with continued medical therapy for treatment of refractory angina pectoris: a prospective randomised trial: ATLANTIC Investigators. Angina Treatments-Lasers and Normal Therapies in Comparison. *Lancet*. 1999;354: 885-90.
206. Allen KB, Dowling RD, DelRossi AJ, et al. Transmyocardial laser revascularization combined with coronary artery bypass grafting: a multicenter, blinded, prospective, randomized, controlled trial. *J Thorac Cardiovasc Surg*. 2000;119: 540-9.
207. Stamou SC, Boyce SW, Cooke RH, et al. One-year outcome after combined coronary artery bypass grafting and transmyocardial laser revascularization for refractory angina pectoris. *Am J Cardiol*. 2002;89:1365-8.
208. Grines CL, Bonow RO, Casey DE Jr, et al. Prevention of premature discontinuation of dual antiplatelet therapy in patients with coronary artery stents: a science advisory from the American Heart Association, American College of Cardiology, Society for Cardiovascular Angiography and Interventions, American College of Surgeons, and American Dental Association, with representation from the American College of Physicians. *Circulation*. 2007;115:813-8.
209. Leon MB, Baim DS, Popma JJ, et al. A clinical trial comparing three antithrombotic-drug regimens after coronary-artery stenting: Stent Anticoagulation Restenosis Study Investigators. *N Engl J Med*. 1998;339:1665-71.
210. Mauri L, Hsieh WH, Massaro JM, et al. Stent thrombosis in randomized clinical trials of drug-eluting stents. *N Engl J Med*. 2007;356:1020-9.
211. McFadden EP, Stabile E, Regar E, et al. Late thrombosis in drug-eluting coronary stents after discontinuation of antiplatelet therapy. *Lancet*. 2004;364:1519-21.
212. Bonatti J, Schachner T, Bonaros N, et al. Simultaneous hybrid coronary revascularization using totally endoscopic left internal mammary artery bypass grafting and placement of rapamycin eluting stents in the same interventional session: The COMBINATION pilot study. *Cardiology*. 2008;110:92-5.
213. Gilard M, Bezon E, Cornily JC, et al. Same-day combined percutaneous coronary intervention and coronary artery surgery. *Cardiology*. 2007;108:363-7.
214. Holzhey DM, Jacobs S, Mochalski M, et al. Minimally invasive hybrid coronary artery revascularization. *Ann Thorac Surg*. 2008;86:1856-60.
215. Kon ZN, Brown EN, Tran R, et al. Simultaneous hybrid coronary revascularization reduces postoperative morbidity compared with results from conventional off-pump coronary artery bypass. *J Thorac Cardiovasc Surg*. 2008;135:367-75.
216. Reicher B, Poston RS, Mehra MR, et al. Simultaneous ''hybrid'' percutaneous coronary intervention and minimally invasive surgical bypass grafting: feasibility, safety, and clinical outcomes. *Am Heart J*. 2008;155:661-7.
217. Vassiliades TA Jr, Douglas JS, Morris DC, et al. Integrated coronary revascularization with drug-eluting stents: immediate and seven-month outcome. *J Thorac Cardiovasc Surg*. 2006;131:956-62.
218. Zhao DX, Leacche M, Balaguer JM, et al. Routine intraoperative completion angiography after coronary artery bypass grafting and 1-stop hybrid revascularization results from a fully integrated hybrid catheterization laboratory/operating room. *J Am Coll Cardiol*. 2009;53:232-41.
219. Angelini GD, Wilde P, Salerno TA, et al. Integrated left small thoracotomy and angioplasty for multivessel coronary artery revascularisation. *Lancet*. 1996;347: 757-8.
220. Simoons ML. Myocardial revascularization-bypass surgery or angioplasty? *N Engl J Med*. 1996;335:275-7.
221. Bybee KA, Powell BD, Valeti U, et al. Preoperative aspirin therapy is associated with improved postoperative outcomes in patients undergoing coronary artery bypass grafting. *Circulation*. 2005;112:I286-92.
222. Dacey LJ, Munoz JJ, Johnson ER, et al. Effect of preoperative aspirin use on mortality in coronary artery bypass grafting patients. *Ann Thorac Surg*. 2000; 70:1986-90.
223. Mangano DT, Multicenter Study of Perioperative Ischemia Research Group. Aspirin and mortality from coronary bypass surgery. *N Engl J Med*. 2002; 347:1309-17.
224. Berger JS, Frye CB, Harshaw Q, et al. Impact of clopidogrel in patients with acute coronary syndromes requiring coronary artery bypass surgery: a multicenter analysis. *J Am Coll Cardiol*. 2008;52:1693-701.
225. Held C, Asenblad N, Bassand JP, et al. Ticagrelor versus clopidogrel in patients with acute coronary syndromes undergoing coronary artery bypass surgery: results from the PLATO (Platelet Inhibition and Patient Outcomes) trial. *J Am Coll Cardiol*. 2010;57:672-84.
226. Hongo RH, Ley J, Dick SE, et al. The effect of clopidogrel in combination with aspirin when given before coronary artery bypass grafting. *J Am Coll Cardiol*. 2002;40:231-7.
227. Firanescu CE, Martens EJ, Schonberger JP, et al. Postoperative blood loss in patients undergoing coronary artery bypass surgery after preoperative treatment with clopidogrel: A prospective randomised controlled study. *Eur J Cardiothorac Surg*. 2009;36:856-62.
228. Herman CR, Buth KJ, Kent BA, et al. Clopidogrel increases blood transfusion and hemorrhagic complications in patients undergoing cardiac surgery. *Ann Thorac Surg*. 2010;89:397-402.
229. Mehta RH, Sheng S, O'Brien SM, et al. Reoperation for bleeding in patients undergoing coronary artery bypass surgery: incidence, risk factors, time trends, and outcomes. *Circ Cardiovasc Qual Outcomes*. 2009;2:583-90.

230. Bizzarri F, Scolletta S, Tucci E, et al. Perioperative use of tirofiban hydrochloride (Aggrastat) does not increase surgical bleeding after emergency or urgent coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 2001;122:1181-5.
231. Dyke CM, Bhatia D, Lorenz TJ, et al. Immediate coronary artery bypass surgery after platelet inhibition with eptifibatide: results from PURSUIT: Platelet Glycoprotein IIb/IIIa in Unstable Angina: Receptor Suppression Using Integrelin Therapy. *Ann Thorac Surg*. 2000;70:866-71.
232. Lincoff AM, LeNarz LA, Despotis GJ, et al. Abciximab and bleeding during coronary surgery: results from the EPILOG and EPISTENT trials: Improve Long-term Outcome with abciximab GP IIb/IIIa blockade. Evaluation of Platelet IIb/IIIa Inhibition in STENTing. *Ann Thorac Surg*. 2000;70:516-26.
233. Sethi GK, Copeland JG, Goldman S, et al. Implications of preoperative administration of aspirin in patients undergoing coronary artery bypass grafting: Department of Veterans Affairs Cooperative Study on Antiplatelet Therapy. *J Am Coll Cardiol*. 1990;15:15-20.
234. Collaborative meta-analysis of randomised trials of antiplatelet therapy for prevention of death, myocardial infarction, and stroke in high risk patients [published correction appears in BMJ. 2002;324:141]. *BMJ*. 2002;324: 71-86.
235. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation*. 2002;106: 3143-421.
236. Baigent C, Blackwell L, Emberson J, et al. Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170,000 participants in 26 randomised trials. *Lancet*. 2010;376:1670-81.
237. Pedersen TR, Faergeman O, Kastelein JJ, et al. High-dose atorvastatin vs usual-dose simvastatin for secondary prevention after myocardial infarction: the IDEAL study: a randomized controlled trial [published correction appears in JAMA. 2005;294;3092]. *JAMA*. 2005;294:2437-45.
238. LaRosa JC, Grundy SM, Waters DD, et al. Intensive lipid lowering with atorvastatin in patients with stable coronary disease. *N Engl J Med*. 2005;352:1425-35.
239. Heart Protection Study Collaborative Group. MRC/BHF Heart Protection Study of cholesterol lowering with simvastatin in 20,536 high-risk individuals: a randomised placebo-controlled trial. *Lancet*. 2002;360:7-22.
240. Dotani MI, Elnicki DM, Jain AC, et al. Effect of preoperative statin therapy and cardiac outcomes after coronary artery bypass grafting. *Am J Cardiol*. 2000;86: 1128-30.
241. Mannacio VA, Iorio D, De Amicis V, et al. Effect of rosuvastatin pretreatment on myocardial damage after coronary surgery: a randomized trial. *J Thorac Cardiovasc Surg*. 2008;136:1541-8.
242. Liakopoulos OJ, Choi YH, Haldenwang PL, et al. Impact of preoperative statin therapy on adverse postoperative outcomes in patients undergoing cardiac surgery: a meta-analysis of over 30,000 patients. *Eur Heart J*. 2008;29:1548-59.
243. Knatterud GL, Rosenberg Y, Campeau L, et al. Long-term effects on clinical outcomes of aggressive lowering of low-density lipoprotein cholesterol levels and low-dose anticoagulation in the post coronary artery bypass graft trial: Post CABG Investigators. *Circulation*. 2000;102:157-65.
244. Christenson JT. Preoperative lipid-control with simvastatin reduces the risk of postoperative thrombocytosis and thrombotic complications following CABG. *Eur J Cardiothorac Surg*. 1999;15:394-9.
245. Pascual DA, Arribas JM, Tornel PL, et al. Preoperative statin therapy and troponin T predict early complications of coronary artery surgery. *Ann Thorac Surg*. 2006;81:78-83.
246. Pan W, Pintar T, Anton J, et al. Statins are associated with a reduced incidence of perioperative mortality after coronary artery bypass graft surgery. *Circulation*. 2004;110:II45-9.
247. The Post Coronary Artery Bypass Graft Trial Investigators. The effect of aggressive lowering of low-density lipoprotein cholesterol levels and low-dose anticoagulation on obstructive changes in saphenous-vein coronary-artery bypass grafts. *N Engl J Med*. 1997;336:153-62.
247a. Cholesterol Treatment Trialists' (CTT) Collaboration, Baigent C, Blackwell L, et al. Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170,000 participants in 26 randomised trials. *Lancet*. 2010;376:1670-81.
248. Cannon CP, Braunwald E, McCabe CH, et al. Intensive versus moderate lipid lowering with statins after acute coronary syndromes [published correction appears in *N Engl J Med*. 2006;354:778]. *N Engl J Med*. 2004;350:1495-504.
249. Cannon CP, Steinberg BA, Murphy SA, et al. Meta-analysis of cardiovascular outcomes trials comparing intensive versus moderate statin therapy. *J Am Coll Cardiol*. 2006;48:438-45.
250. Grundy SM, Cleeman JI, Merz CN, et al. Implications of recent clinical trials for the National Cholesterol Education Program Adult Treatment Panel III guidelines. *Circulation*. 2004;110:227-39.
250a. FDA Safety Alert. Zocor (simvastatin): increased risk of muscleinjury with high doses. U.S. Department of Health and HumanServices. 2011. Available at: http://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/ucm205404.htm. Accessed June 30, 2011.
251. Collard CD, Body SC, Shernan SK, et al. Preoperative statin therapy is associated with reduced cardiac mortality after coronary artery bypass graft surgery. *J Thorac Cardiovasc Surg*. 2006;132:392-400.
252. Kulik A, Brookhart MA, Levin R, et al. Impact of statin use on outcomes after coronary artery bypass graft surgery. *Circulation*. 2008;118:1785-92.
253. Thielmann M, Neuhauser M, Marr A, et al. Lipid-lowering effect of preoperative statin therapy on postoperative major adverse cardiac events after coronary artery bypass surgery. *J Thorac Cardiovasc Surg*. 2007;134:1143-9.
254. Furnary AP, Gao G, Grunkemeier GL, et al. Continuous insulin infusion reduces mortality in patients with diabetes undergoing coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 2003;125:1007-21.
255. Ingels C, Debaveye Y, Milants I, et al. Strict blood glucose control with insulin during intensive care after cardiac surgery: impact on 4-years survival, dependency on medical care, and quality-of-life. *Eur Heart J*. 2006;27: 2716-24.
256. van den Berghe G, Wouters P, Weekers F, et al. Intensive insulin therapy in the critically ill patients. *N Engl J Med*. 2001;345:1359-67.
257. Butterworth J, Wagenknecht LE, Legault C, et al. Attempted control of hyperglycemia during cardiopulmonary bypass fails to improve neurologic or neurobehavioral outcomes in patients without diabetes mellitus undergoing coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 2005;130:1319.
258. Duncan AE, Abd-Elsayed A, Maheshwari A, et al. Role of intraoperative and postoperative blood glucose concentrations in predicting outcomes after cardiac surgery. *Anesthesiology.* 2010;112:860-71.
259. Gandhi GY, Nuttall GA, Abel MD, et al. Intensive intraoperative insulin therapy versus conventional glucose management during cardiac surgery: a randomized trial. *Ann Intern Med*. 2007;146:233-43.
260. Hulley S, Grady D, Bush T, et al. Randomized trial of estrogen plus progestin for secondary prevention of coronary heart disease in postmenopausal women: Heart and Estrogen/progestin Replacement Study (HERS) Research Group. *JAMA*. 1998;280:605-13.
261. Rossouw JE, Anderson GL, Prentice RL, et al. Risks and benefits of estrogen plus progestin in healthy postmenopausal women: principal results From the Women's Health Initiative randomized controlled trial. *JAMA*. 2002;288:321-33.
262. Ouyang P, Tardif JC, Herrington DM, et al. Randomized trial of hormone therapy in women after coronary bypass surgery: Evidence of differential effect of hormone therapy on angiographic progression of disease in saphenous vein grafts and native coronary arteries. *Atherosclerosis*. 2006;189:375-86.
263. Crystal E, Garfinkle MS, Connolly SS, et al. Interventions for preventing postoperative atrial fibrillation in patients undergoing heart surgery. *Cochrane Database Syst Rev.* 2004;CD003611.
264. Connolly SJ, Cybulsky I, Lamy A, et al. Double-blind, placebo-controlled, randomized trial of prophylactic metoprolol for reduction of hospital length of stay after heart surgery: the beta-Blocker Length Of Stay (BLOS) study. *Am Heart J*. 2003;145:226-32.
265. Andrews TC, Reimold SC, Berlin JA, et al. Prevention of supraventricular arrhythmias after coronary artery bypass surgery: A meta-analysis of randomized control trials. *Circulation*. 1991;84:III236-44.
266. Al-Khatib SM, Hafley G, Harrington RA, et al. Patterns of management of atrial fibrillation complicating coronary artery bypass grafting: results from the PRoject of Ex-vivo Vein graft ENgineering via Transfection IV (PREVENT-IV) Trial. *Am Heart J*. 2009;158:792-8.
267. Mariscalco G, Klersy C, Zanobini M, et al. Atrial fibrillation after isolated coronary surgery affects late survival. *Circulation*. 2008;118:1612-8.
267a. Silverman NA, Wright R, Levitsky S. Efficacy of low-dose propranolol in preventing postoperative supraventricular tachyarrhythmias: a prospective, randomized study. *Ann Surg*. 1982;196:194-7.
267b. Ali IM, Sanalla AA, Clark V. Beta-blocker effects on postoperative atrial fibrillation. *Eur J Cardiothorac Surg*. 1997;11:1154-7.
267c. Fuster V, Ryden LE, Cannom DS, et al. 2011 ACCF/AHA/HRS focused updates incorporated into the ACC/AHA/ESC 2006 guidelines for the management of patients with atrial fibrillation: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2011;57:e101-98.

268. Ferguson TB Jr, Coombs LP, Peterson ED. Preoperative beta-blocker use and mortality and morbidity following CABG surgery in North America. *JAMA*. 2002;287:2221-7.
269. ten Broecke P, De Hert S, Mertens E. Effect of preoperative beta-blockade on perioperative mortality in coronary surgery. *Br J Anaesth*. 2003;90:27-31.
270. Weightman WM, Gibbs NM, Sheminant MR, et al. Drug therapy before coronary artery surgery: nitrates are independent predictors of mortality and beta-adrenergic blockers predict survival. *Anesth Analg*. 1999;88:286-91.
271. Chung F, Houston PL, Cheng DC, et al. Calcium channel blockade does not offer adequate protection from perioperative myocardial ischemia. *Anesthesiology.* 1988;69:343-7.
272. Podesser BK, Schwarzacher S, Zwoelfer W, et al. Comparison of perioperative myocardial protection with nifedipine versus nifedipine and metoprolol in patients undergoing elective coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 1995;110:1461-9.
273. Slogoff S, Keats AS. Does chronic treatment with calcium entry blocking drugs reduce perioperative myocardial ischemia? *Anesthesiology.* 1988;68: 676-80.
274. Wiesbauer F, Schlager O, Domanovits H, et al. Perioperative beta-blockers for preventing surgery-related mortality and morbidity: a systematic review and meta-analysis. *Anesth Analg*. 2007;104:27-41.
275. Halonen J, Hakala T, Auvinen T, et al. Intravenous administration of metoprolol is more effective than oral administration in the prevention of atrial fibrillation after cardiac surgery. *Circulation*. 2006;114:I1-4.
276. Lin T, Hasaniya NW, Krider S, et al. Mortality reduction with beta-blockers in ischemic cardiomyopathy patients undergoing coronary artery bypass grafting. *Congest Heart Fail*. 2010;16:170-4.
277. Smith SC Jr, Allen J, Blair SN, et al. AHA/ACC guidelines for secondary prevention for patients with coronary and other atherosclerotic vascular disease: 2006 update. *J Am Coll Cardiol*. 2006;47:2130-9.
278. Goyal A, Alexander JH, Hafley GE, et al. Outcomes associated with the use of secondary prevention medications after coronary artery bypass graft surgery. *Ann Thorac Surg*. 2007;83:993-1001.
279. Oosterga M, Voors AA, Pinto YM, et al. Effects of quinapril on clinical outcome after coronary artery bypass grafting (The QUO VADIS Study): QUinapril on Vascular Ace and Determinants of Ischemia. *Am J Cardiol*. 2001;87:542-6.
279a. Collaborative Group on ACE Inhibitor Trials. Overview of randomized trials of angiotensin-converting enzyme inhibitors on mortality and morbidity in patients with heart failure. *JAMA*. 1995;273:1450-6.
279b. The Heart Outcomes Prevention Evaluation Study Investigators. Effects of an angiotensin-converting enzyme inhibitor, ramipril, on cardiovascular events in high risk patients. [published corrections appear in *N Engl J Med.* 2000;342:1376; 2000;342:748]. *N Engl J Med.* 2000;342:145-53.
280. Fox KM, Bertrand ME, Remme WJ, et al. Efficacy of perindopril in reducing risk of cardiac events in patients with revascularized coronary artery disease. *Am Heart J*. 2007;153:629-35.
281. Kjoller-Hansen L, Steffensen R, Grande P. The Angiotensin-converting Enzyme Inhibition Post Revascularization Study (APRES). *J Am Coll Cardiol*. 2000;35:881-8.
282. Rouleau JL, Warnica WJ, Baillot R, et al. Effects of angiotensin-converting enzyme inhibition in low-risk patients early after coronary artery bypass surgery. *Circulation*. 2008;117:24-31.
283. Arora P, Rajagopalam S, Ranjan R, et al. Preoperative use of angiotensin-converting enzyme inhibitors/angiotensin receptor blockers is associated with increased risk for acute kidney injury after cardiovascular surgery. *Clin J Am Soc Nephrol*. 2008;3:1266-73.
284. Benedetto U, Sciarretta S, Roscitano A, et al. Preoperative Angiotensin-converting enzyme inhibitors and acute kidney injury after coronary artery bypass grafting. *Ann Thorac Surg*. 2008;86:1160-5.
285. Levin MA, Lin HM, Castillo JG, et al. Early on-cardiopulmonary bypass hypotension and other factors associated with vasoplegic syndrome. *Circulation*. 2009;120:1664-71.
286. Miceli A, Capoun R, Fino C, et al. Effects of angiotensin-converting enzyme inhibitor therapy on clinical outcome in patients undergoing coronary artery bypass grafting. *J Am Coll Cardiol*. 2009;54:1778-84.
287. Rader F, Van Wagoner DR, Gillinov AM, et al. Preoperative angiotensin-blocking drug therapy is not associated with atrial fibrillation after cardiac surgery. *Am Heart J*. 2010;160:329-36. e1.
288. White CM, Kluger J, Lertsburapa K, et al. Effect of preoperative angiotensin converting enzyme inhibitor or angiotensin receptor blocker use on the frequency of atrial fibrillation after cardiac surgery: a cohort study from the atrial fibrillation suppression trials II and III. *Eur J Cardiothorac Surg*. 2007;31: 817-20.
289. Eagle KA, Guyton RA, Davidoff R, et al. ACC/AHA 2004 guideline update for coronary artery bypass graft surgery: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1999 Guidelines for Coronary Artery Bypass Graft Surgery). *J Am Coll Cardiol*. 2004;44:e213-310.
290. Deleted in proof.
291. Hilleman DE, Mohiuddin SM, Packard KA. Comparison of conservative and aggressive smoking cessation treatment strategies following coronary artery bypass graft surgery. *Chest*. 2004;125:435-8.
292. Rigotti NA, Munafo MR, Stead LF. Smoking cessation interventions for hospitalized smokers: a systematic review. *Arch Intern Med*. 2008;168: 1950-60.
293. Smith PM, Burgess E. Smoking cessation initiated during hospital stay for patients with coronary artery disease: a randomized controlled trial. *CMAJ*. 2009; 180:1297-303.
293a. Anthonisen NR, Skeans MA, Wise RA, et al. The effects of a smoking cessation intervention on 14.5-year mortality: a randomized clinical trial. *Ann Intern Med*. 2005;142:233-9.
294. Blumenthal JA, Lett HS, Babyak MA, et al. Depression as a risk factor for mortality after coronary artery bypass surgery. *Lancet*. 2003;362:604-9.
295. Connerney I, Shapiro PA, McLaughlin JS, et al. Relation between depression after coronary artery bypass surgery and 12-month outcome: a prospective study. *Lancet*. 2001;358:1766-71.
296. Freedland KE, Skala JA, Carney RM, et al. Treatment of depression after coronary artery bypass surgery: a randomized controlled trial. *Arch Gen Psychiatry.* 2009;66:387-96.
297. Rollman BL, Belnap BH, LeMenager MS, et al. Telephone-delivered collaborative care for treating post-CABG depression: a randomized controlled trial. *JAMA*. 2009;302:2095-103.
298. Rollman BL, Belnap BH, LeMenager MS, et al. The Bypassing the Blues treatment protocol: stepped collaborative care for treating post-CABG depression. *Psychosom Med*. 2009;71:217-30.
299. Engblom E, Korpilahti K, Hamalainen H, et al. Quality of life and return to work 5 years after coronary artery bypass surgery: Long-term results of cardiac rehabilitation. *J Cardiopulm Rehabil*. 1997;17:29-36.
300. Hansen D, Dendale P, Leenders M, et al. Reduction of cardiovascular event rate: different effects of cardiac rehabilitation in CABG and PCI patients. *Acta Cardiol*. 2009;64:639-44.
301. Milani RV, Lavie CJ. The effects of body composition changes to observed improvements in cardiopulmonary parameters after exercise training with cardiac rehabilitation. *Chest*. 1998;113:599-601.
301a. Taylor RS, Brown A, Ebrahim S, et al. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. *Am J Med*. 2004;116:682-92.
301b. Clark AM, Hartling L, Vandermeer B, McAlister FA. Meta-analysis: secondary prevention programs for patients with coronary artery disease. *Ann Intern Med*. 2005;143:659-72.
301c. Thomas RJ, King M, Lui K, et al. AACVPR/ACC/AHA 2007 performance measures on cardiac rehabilitation for referral to and delivery of cardiac rehabilitation/ secondary prevention services. *J Am Coll Cardiol*. 2007;50:1400-33.
301d. Walther C, Mobius-Winkler S, Linke A, et al. Regular exercise training compared with percutaneous intervention leads to a reduction of inflammatory markers and cardiovascular events in patients with coronary artery disease. *Eur J Cardiovasc Prev Rehabil*. 2008;15:107-12.
302. Drew BJ, Califf RM, Funk M, et al. Practice standards for electrocardiographic monitoring in hospital settings: an American Heart Association scientific statement from the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young. *Circulation* [published correction appears in *Circulation*. 2005;111:378]. 2004;110:2721-46.
303. Echahidi N, Pibarot P, O'Hara G, et al. Mechanisms, prevention, and treatment of atrial fibrillation after cardiac surgery. *J Am Coll Cardiol*. 2008;51: 793-801.
304. Gordon MA, Urban MK, O'Connor T, et al. Is the pressure rate quotient a predictor or indicator of myocardial ischemia as measured by ST-segment changes in patients undergoing coronary artery bypass surgery? *Anesthesiology.* 1991; 74:848-53.
305. Jain U, Laflamme CJ, Aggarwal A, et al. Electrocardiographic and hemodynamic changes and their association with myocardial infarction during coronary

artery bypass surgery: A multicenter study. Multicenter Study of Perioperative Ischemia (McSPI) Research Group. *Anesthesiology.* 1997;86:576-91.
306. Knight AA, Hollenberg M, London MJ, et al. Perioperative myocardial ischemia: importance of the preoperative ischemic pattern. *Anesthesiology.* 1988; 68:681-8.
307. Mangano DT, Siliciano D, Hollenberg M, et al. Postoperative myocardial ischemia: Therapeutic trials using intensive analgesia following surgery. The Study of Perioperative Ischemia (SPI) Research Group. *Anesthesiology.* 1992;76: 342-53.
308. Zvara DA, Groban L, Rogers AT, et al. Prophylactic nitroglycerin did not reduce myocardial ischemia during accelerated recovery management of coronary artery bypass graft surgery patients. *J Cardiothorac Vasc Anesth*. 2000;14:571-5.
309. Berry PD, Thomas SD, Mahon SP, et al. Myocardial ischaemia after coronary artery bypass grafting: early vs late extubation [published corrections appear in Br J Anaesth. 1998;80:572; 1998;81:111]. *Br J Anaesth*. 1998;80:20-5.
310. Cheng DC, Karski J, Peniston C, et al. Morbidity outcome in early versus conventional tracheal extubation after coronary artery bypass grafting: a prospective randomized controlled trial. *J Thorac Cardiovasc Surg*. 1996;112:755-64.
311. Practice guidelines for pulmonary artery catheterization: an updated report by the American Society of Anesthesiologists Task Force on Pulmonary Artery Catheterization. *Anesthesiology.* 2003;99:988-1014.
312. Pearson KS, Gomez MN, Moyers JR, et al. A cost/benefit analysis of randomized invasive monitoring for patients undergoing cardiac surgery. *Anesth Analg*. 1989;69:336-41.
313. Resano FG, Kapetanakis EI, Hill PC, et al. Clinical outcomes of low-risk patients undergoing beating-heart surgery with or without pulmonary artery catheterization. *J Cardiothorac Vasc Anesth*. 2006;20:300-6.
314. Schwann TA, Zacharias A, Riordan CJ, et al. Safe, highly selective use of pulmonary artery catheters in coronary artery bypass grafting: an objective patient selection method. *Ann Thorac Surg*. 2002;73:1394-401.
315. Stewart RD, Psyhojos T, Lahey SJ, et al. Central venous catheter use in low-risk coronary artery bypass grafting. *Ann Thorac Surg*. 1998;66:1306-11.
316. Tuman KJ, McCarthy RJ, Spiess BD, et al. Effect of pulmonary artery catheterization on outcome in patients undergoing coronary artery surgery. *Anesthesiology.* 1989;70:199-206.
317. Brady K, Joshi B, Zweifel C, et al. Real-time continuous monitoring of cerebral blood flow autoregulation using near-infrared spectroscopy in patients undergoing cardiopulmonary bypass. *Stroke*. 2010;41:1951-6.
318. Murkin JM, Adams SJ, Novick RJ, et al. Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study. *Anesth Analg*. 2007;104:51-8.
319. Slater JP, Guarino T, Stack J, et al. Cerebral oxygen desaturation predicts cognitive decline and longer hospital stay after cardiac surgery. *Ann Thorac Surg*. 2009;87:36-44.
320. Geraci JM, Johnson ML, Gordon HS, et al. Mortality after cardiac bypass surgery: prediction from administrative versus clinical data. *Med Care*. 2005;43: 149-58.
321. Hannan EL, Kilburn H Jr, Lindsey ML, et al. Clinical versus administrative data bases for CABG surgery: Does it matter? *Med Care*. 1992;30:892-907.
322. Hannan EL, Racz MJ, Jollis JG, et al. Using Medicare claims data to assess provider quality for CABG surgery: does it work well enough? *Health Serv Res*. 1997;31:659-78.
323. Hartz AJ, Kuhn EM. Comparing hospitals that perform coronary artery bypass surgery: the effect of outcome measures and data sources. *Am J Public Health*. 1994;84:1609-14.
324. Jones RH, Hannan EL, Hammermeister KE, et al. Identification of preoperative variables needed for risk adjustment of short-term mortality after coronary artery bypass graft surgery: The Working Group Panel on the Cooperative CABG Database Project. *J Am Coll Cardiol*. 1996;28:1478-87.
325. Mack MJ, Herbert M, Prince S, et al. Does reporting of coronary artery bypass grafting from administrative databases accurately reflect actual clinical outcomes? *J Thorac Cardiovasc Surg*. 2005;129:1309-17.
326. Shahian DM, Silverstein T, Lovett AF, et al. Comparison of clinical and administrative data sources for hospital coronary artery bypass graft surgery report cards. *Circulation*. 2007;115:1518-27.
327. Tu JV, Sykora K, Naylor CD. Assessing the outcomes of coronary artery bypass graft surgery: how many risk factors are enough?: Steering Committee of the Cardiac Care Network of Ontario. *J Am Coll Cardiol*. 1997;30:1317-23.
328. Clark RE. Outcome as a function of annual coronary artery bypass graft volume: The Ad Hoc Committee on Cardiac Surgery Credentialing of The Society of Thoracic Surgeons. *Ann Thorac Surg*. 1996;61:21-6.
329. Grumbach K, Anderson GM, Luft HS, et al. Regionalization of cardiac surgery in the United States and Canada: Geographic access, choice, and outcomes. *JAMA*. 1995;274:1282-8.
330. Hannan EL, Kilburn H Jr, Bernard H, et al. Coronary artery bypass surgery: the relationship between inhospital mortality rate and surgical volume after controlling for clinical risk factors. *Med Care*. 1991;29:1094-107.
331. Hannan EL, Siu AL, Kumar D, et al. The decline in coronary artery bypass graft surgery mortality in New York State: The role of surgeon volume. *JAMA*. 1995; 273:209-13.
332. Hannan EL, Wu C, Ryan TJ, et al. Do hospitals and surgeons with higher coronary artery bypass graft surgery volumes still have lower risk-adjusted mortality rates? *Circulation*. 2003;108:795-801.
333. Kalant N, Shrier I. Volume and outcome of coronary artery bypass graft surgery: are more and less the same? *Can J Cardiol*. 2004;20:81-6.
334. Nallamothu BK, Saint S, Ramsey SD, et al. The role of hospital volume in coronary artery bypass grafting: is more always better? *J Am Coll Cardiol*. 2001; 38:1923-30.
335. Peterson ED, Coombs LP, DeLong ER, et al. Procedural volume as a marker of quality for CABG surgery. *JAMA*. 2004;291:195-201.
336. Rathore SS, Epstein AJ, Volpp KG, et al. Hospital coronary artery bypass graft surgery volume and patient mortality, 1998-2000. *Ann Surg*. 2004;239:110-7.
337. Shahian DM, O'Brien SM, Normand SL, et al. Association of hospital coronary artery bypass volume with processes of care, mortality, morbidity, and the Society of Thoracic Surgeons composite quality score. *J Thorac Cardiovasc Surg*. 2010;139:273-82.
338. Showstack JA, Rosenfeld KE, Garnick DW, et al. Association of volume with outcome of coronary artery bypass graft surgery: Scheduled vs nonscheduled operations. *JAMA*. 1987;257:785-9.
339. Shroyer AL, Marshall G, Warner BA, et al. No continuous relationship between Veterans Affairs hospital coronary artery bypass grafting surgical volume and operative mortality. *Ann Thorac Surg*. 1996;61:17-20.
340. Sowden AJ, Deeks JJ, Sheldon TA. Volume and outcome in coronary artery bypass graft surgery: true association or artefact? *BMJ*. 1995;311:151-5.
341. Welke KF, Barnett MJ, Sarrazin MS, et al. Limitations of hospital volume as a measure of quality of care for coronary artery bypass graft surgery. *Ann Thorac Surg*. 2005;80:2114-9.
342. Wu C, Hannan EL, Ryan TJ, et al. Is the impact of hospital and surgeon volumes on the in-hospital mortality rate for coronary artery bypass graft surgery limited to patients at high risk? *Circulation*. 2004;110:784-9.
343. Nakamura M, Okamoto F, Nakanishi K, et al. Does intensive management of cerebral hemodynamics and atheromatous aorta reduce stroke after coronary artery surgery? *Ann Thorac Surg*. 2008;85:513-9.
344. Rosenberger P, Shernan SK, Loffler M, et al. The influence of epiaortic ultrasonography on intraoperative surgical management in 6051 cardiac surgical patients. *Ann Thorac Surg*. 2008;85:548-53.
345. Yamaguchi A, Adachi H, Tanaka M, et al. Efficacy of intraoperative epiaortic ultrasound scanning for preventing stroke after coronary artery bypass surgery. *Ann Thorac Cardiovasc Surg*. 2009;15:98-104.
346. Durand DJ, Perler BA, Roseborough GS, et al. Mandatory versus selective preoperative carotid screening: a retrospective analysis. *Ann Thorac Surg*. 2004;78: 159-66.
347. Sheiman RG, Janne d'Othee B. Screening carotid sonography before elective coronary artery bypass graft surgery: who needs it [published correction appears in *Am J Roentgenol.* 2007;189:512]. *Am J Roentgenol*. 2007;188:W475-9.
348. Kreter B, Woods M. Antibiotic prophylaxis for cardiothoracic operations: Meta-analysis of thirty years of clinical trials. *J Thorac Cardiovasc Surg*. 1992;104:590-9.
349. Goodman JS, Schaffner W, Collins HA, et al. Infection after cardiovascular surgery: Clinical study including examination of antimicrobial prophylaxis. *N Engl J Med*. 1968;278:117-23.
350. Fong IW, Baker CB, McKee DC. The value of prophylactic antibiotics in aortacoronary bypass operations: a double-blind randomized trial. *J Thorac Cardiovasc Surg*. 1979;78:908-13.
351. Fekety FR Jr, Cluff LE, Sabiston DC Jr, et al. A study of antibiotic prophylaxis in cardiac surgery. *J Thorac Cardiovasc Surg*. 1969;57:757-63.
352. Austin TW, Coles JC, Burnett R, et al. Aortocoronary bypass procedures and sternotomy infections: a study of antistaphylococcal prophylaxis. *Can J Surg*. 1980;23:483-5.
353. Kaiser AB, Petracek MR, Lea JW, et al. Efficacy of cefazolin, cefamandole, and gentamicin as prophylactic agents in cardiac surgery: Results of a prospective, randomized, double-blind trial in 1030 patients. *Ann Surg*. 1987;206:791-7.

354. Bolon MK, Morlote M, Weber SG, et al. Glycopeptides are no more effective than beta-lactam agents for prevention of surgical site infection after cardiac surgery: a meta-analysis. *Clin Infect Dis*. 2004;38:1357-63.
355. Finkelstein R, Rabino G, Mashiah T, et al. Vancomycin versus cefazolin prophylaxis for cardiac surgery in the setting of a high prevalence of methicillin-resistant staphylococcal infections. *J Thorac Cardiovasc Surg*. 2002;123:326-32.
356. Maki DG, Bohn MJ, Stolz SM, et al. Comparative study of cefazolin, cefamandole, and vancomycin for surgical prophylaxis in cardiac and vascular operations: A double-blind randomized trial. *J Thorac Cardiovasc Surg*. 1992;104:1423-34.
357. Saginur R, Croteau D, Bergeron MG. Comparative efficacy of teicoplanin and cefazolin for cardiac operation prophylaxis in 3027 patients: The ESPRIT Group. *J Thorac Cardiovasc Surg*. 2000;120:1120-30.
358. Salminen US, Viljanen TU, Valtonen VV, et al. Ceftriaxone versus vancomycin prophylaxis in cardiovascular surgery. *J Antimicrob Chemother.* 1999;44:287-90.
359. Townsend TR, Reitz BA, Bilker WB, et al. Clinical trial of cefamandole, cefazolin, and cefuroxime for antibiotic prophylaxis in cardiac operations. *J Thorac Cardiovasc Surg*. 1993;106:664-70.
360. Vuorisalo S, Pokela R, Syrjala H. Comparison of vancomycin and cefuroxime for infection prophylaxis in coronary artery bypass surgery. *Infect Control Hosp Epidemiol*. 1998;19:234-9.
361. Wilson AP, Treasure T, Gruneberg RN, et al. Antibiotic prophylaxis in cardiac surgery: a prospective comparison of two dosage regimens of teicoplanin with a combination of flucloxacillin and tobramycin. *J Antimicrob Chemother.* 1988; 21:213-23.
362. Centers for Diseases Control and Prevention. Recommendations for preventing the spread of vancomycin resistance: Recommendations of the Hospital Infection Control Practices Advisory Committee. *MMWR Morb Mortal Wkly Rep*. 2010;44:1-13.
363. Spelman D, Harrington G, Russo P, et al. Clinical, microbiological, and economic benefit of a change in antibiotic prophylaxis for cardiac surgery. *Infect Control Hosp Epidemiol*. 2002;23:402-4.
364. Walsh EE, Greene L, Kirshner R. Sustained reduction in methicillin-resistant Staphylococcus aureus wound infections after cardiothoracic surgery. *Arch Intern Med*. 2010;171:68-73.
365. Jurkiewicz MJ, Bostwick J III, Hester TR, et al. Infected median sternotomy wound: Successful treatment by muscle flaps. *Ann Surg*. 1980;191:738-44.
366. Rand RP, Cochran RP, Aziz S, et al. Prospective trial of catheter irrigation and muscle flaps for sternal wound infection. *Ann Thorac Surg*. 1998;65:1046-9.
367. Wong CH, Senewiratne S, Garlick B, et al. Two-stage management of sternal wound infection using bilateral pectoralis major advancement flap. *Eur J Cardiothorac Surg*. 2006;30:148-52.
368. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg*. 1997;38:563-76.
369. Baillot R, Cloutier D, Montalin L, et al. Impact of deep sternal wound infection management with vacuum-assisted closure therapy followed by sternal osteosynthesis: a 15-year review of 23,499 sternotomies. *Eur J Cardiothorac Surg*. 2010;37:880-7.
370. Cowan KN, Teague L, Sue SC, et al. Vacuum-assisted wound closure of deep sternal infections in high-risk patients after cardiac surgery. *Ann Thorac Surg*. 2005;80:2205-12.
371. Doss M, Martens S, Wood JP, et al. Vacuum-assisted suction drainage versus conventional treatment in the management of poststernotomy osteomyelitis. *Eur J Cardiothorac Surg*. 2002;22:934-8.
372. Ennker IC, Malkoc A, Pietrowski D, et al. The concept of negative pressure wound therapy (NPWT) after poststernotomy mediastinitis: a single center experience with 54 patients. *J Cardiothorac Surg*. 2009;4:5.
373. Fleck T, Moidl R, Giovanoli P, et al. A conclusion from the first 125 patients treated with the vacuum assisted closure system for postoperative sternal wound infection. *Interact Cardiovasc Thorac Surg*. 2006;5:145-8.
374. Fleck TM, Fleck M, Moidl R, et al. The vacuum-assisted closure system for the treatment of deep sternal wound infections after cardiac surgery. *Ann Thorac Surg*. 2002;74:1596-600.
375. Luckraz H, Murphy F, Bryant S, et al. Vacuum-assisted closure as a treatment modality for infections after cardiac surgery. *J Thorac Cardiovasc Surg*. 2003;125:301-5.
376. Sjogren J, Gustafsson R, Nilsson J, et al. Clinical outcome after poststernotomy mediastinitis: vacuum-assisted closure versus conventional treatment. *Ann Thorac Surg*. 2005;79:2049-55.
377. Sjogren J, Nilsson J, Gustafsson R, et al. The impact of vacuum-assisted closure on long-term survival after post-sternotomy mediastinitis. *Ann Thorac Surg*. 2005;80:1270-5.
378. Doenst T, Wijeysundera D, Karkouti K, et al. Hyperglycemia during cardiopulmonary bypass is an independent risk factor for mortality in patients undergoing cardiac surgery. *J Thorac Cardiovasc Surg*. 2005;130:1144.
379. Furnary AP, Wu Y. Eliminating the diabetic disadvantage: the Portland Diabetic Project. *Semin Thorac Cardiovasc Surg*. 2006;18:302-8.
380. Kirdemir P, Yildirim V, Kiris I, et al. Does continuous insulin therapy reduce postoperative supraventricular tachycardia incidence after coronary artery bypass operations in diabetic patients? *J Cardiothorac Vasc Anesth*. 2008;22:383-7.
381. Ouattara A, Lecomte P, Le Manach Y, et al. Poor intraoperative blood glucose control is associated with a worsened hospital outcome after cardiac surgery in diabetic patients. *Anesthesiology.* 2005;103:687-94.
382. Bilgin YM, van de Watering LM, Eijsman L, et al. Double-blind, randomized controlled trial on the effect of leukocyte-depleted erythrocyte transfusions in cardiac valve surgery. *Circulation*. 2004;109:2755-60.
383. Blumberg N, Heal JM, Cowles JW, et al. Leukocyte-reduced transfusions in cardiac surgery results of an implementation trial. *Am J Clin Pathol*. 2002;118: 376-81.
384. Romano G, Mastroianni C, Bancone C, et al. Leukoreduction program for red blood cell transfusions in coronary surgery: association with reduced acute kidney injury and in-hospital mortality. *J Thorac Cardiovasc Surg*. 2010;140:188-95.
385. van de Watering LM, Hermans J, Houbiers JG, et al. Beneficial effects of leukocyte depletion of transfused blood on postoperative complications in patients undergoing cardiac surgery: a randomized clinical trial. *Circulation*. 1998;97: 562-8.
386. Konvalinka A, Errett L, Fong IW. Impact of treating Staphylococcus aureus nasal carriers on wound infections in cardiac surgery. *J Hosp Infect*. 2006;64: 162-8.
387. van Rijen M, Bonten M, Wenzel R, et al. Mupirocin ointment for preventing Staphylococcus aureus infections in nasal carriers. *Cochrane Database Syst Rev.* 2008;CD006216.
388. Ascione R, Nason G, Al-Ruzzeh S, et al. Coronary revascularization with or without cardiopulmonary bypass in patients with preoperative nondialysis-dependent renal insufficiency. *Ann Thorac Surg*. 2001;72:2020-5.
389. Chukwuemeka A, Weisel A, Maganti M, et al. Renal dysfunction in high-risk patients after on-pump and off-pump coronary artery bypass surgery: a propensity score analysis. *Ann Thorac Surg*. 2005;80:2148-53.
390. Di Mauro M, Gagliardi M, Iaco AL, et al. Does off-pump coronary surgery reduce postoperative acute renal failure? The importance of preoperative renal function. *Ann Thorac Surg*. 2007;84:1496-502.
391. Nigwekar SU, Kandula P, Hix JK, et al. Off-pump coronary artery bypass surgery and acute kidney injury: a meta-analysis of randomized and observational studies. *Am J Kidney Dis*. 2009;54:413-23.
392. Sajja LR, Mannam G, Chakravarthi RM, et al. Coronary artery bypass grafting with or without cardiopulmonary bypass in patients with preoperative non-dialysis dependent renal insufficiency: a randomized study. *J Thorac Cardiovasc Surg*. 2007;133:378-88.
393. Del Duca D, Iqbal S, Rahme E, et al. Renal failure after cardiac surgery: timing of cardiac catheterization and other perioperative risk factors. *Ann Thorac Surg*. 2007;84:1264-71.
394. Medalion B, Cohen H, Assali A, et al. The effect of cardiac angiography timing, contrast media dose, and preoperative renal function on acute renal failure after coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 2010;139: 1539-44.
395. Ranucci M, Ballotta A, Kunkl A, et al. Influence of the timing of cardiac catheterization and the amount of contrast media on acute renal failure after cardiac surgery. *Am J Cardiol*. 2008;101:1112-8.
396. Adabag AS, Ishani A, Bloomfield HE, et al. Efficacy of N-acetylcysteine in preventing renal injury after heart surgery: a systematic review of randomized trials. *Eur Heart J*. 2009;30:1910-7.
397. Amar D, Fleisher M. Diltiazem treatment does not alter renal function after thoracic surgery. *Chest*. 2001;119:1476-9.
398. Caimmi PP, Pagani L, Micalizzi E, et al. Fenoldopam for renal protection in patients undergoing cardiopulmonary bypass. *J Cardiothorac Vasc Anesth*. 2003;17:491-4.
399. Cogliati AA, Vellutini R, Nardini A, et al. Fenoldopam infusion for renal protection in high-risk cardiac surgery patients: a randomized clinical study. *J Cardiothorac Vasc Anesth*. 2007;21:847-50.
400. Davis RF, Giesecke NM. Hemodilution and priming solutions. In: Gravlee GP, Davis RF, Kurusz M, Utley JR, editors. Cardiopulmonary Bypass: Principles and Practice. 2nd ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2000:186-196.

401. El-Hamamsy I, Stevens LM, Carrier M, et al. Effect of intravenous N-acetylcysteine on outcomes after coronary artery bypass surgery: a randomized, double-blind, placebo-controlled clinical trial. *J Thorac Cardiovasc Surg*. 2007;133:7-12.
402. Fansa I, Gol M, Nisanoglu V, et al. Does diltiazem inhibit the inflammatory response in cardiopulmonary bypass? *Med Sci Monit*. 2003;9:PI30-6.
403. Fischer UM, Tossios P, Mehlhorn U. Renal protection by radical scavenging in cardiac surgery patients. *Curr Med Res Opin*. 2005;21:1161-4.
404. Friedrich JO, Adhikari N, Herridge MS, et al. Meta-analysis: low-dose dopamine increases urine output but does not prevent renal dysfunction or death. *Ann Intern Med*. 2005;142:510-24.
405. Haase M, Haase-Fielitz A, Bagshaw SM, et al. Phase II, randomized, controlled trial of high-dose N-acetylcysteine in high-risk cardiac surgery patients. *Crit Care Med*. 2007;35:1324-31.
406. Ip-Yam PC, Murphy S, Baines M, et al. Renal function and proteinuria after cardiopulmonary bypass: the effects of temperature and mannitol. *Anesth Analg*. 1994;78:842-7.
407. Landoni G, Biondi-Zoccai GG, Tumlin JA, et al. Beneficial impact of fenoldopam in critically ill patients with or at risk for acute renal failure: a meta-analysis of randomized clinical trials. *Am J Kidney Dis*. 2007;49:56-68.
408. Landoni G, Biondi-Zoccai GG, Marino G, et al. Fenoldopam reduces the need for renal replacement therapy and in-hospital death in cardiovascular surgery: a meta-analysis. *J Cardiothorac Vasc Anesth*. 2008;22:27-33.
409. Murphy MB, Murray C, Shorten GD. Fenoldopam: a selective peripheral dopamine-receptor agonist for the treatment of severe hypertension. *N Engl J Med*. 2001;345:1548-57.
410. Nigwekar SU, Hix JK. The role of natriuretic peptide administration in cardiovascular surgery-associated renal dysfunction: a systematic review and meta-analysis of randomized controlled trials. *J Cardiothorac Vasc Anesth*. 2009; 23:151-60.
411. Piper SN, Kumle B, Maleck WH, et al. Diltiazem may preserve renal tubular integrity after cardiac surgery. *Can J Anaesth*. 2003;50:285-92.
412. Ranucci M, Soro G, Barzaghi N, et al. Fenoldopam prophylaxis of postoperative acute renal failure in high-risk cardiac surgery patients. *Ann Thorac Surg*. 2004; 78:1332-7.
413. Ranucci M, De Benedetti D, Bianchini C, et al. Effects of fenoldopam infusion in complex cardiac surgical operations: a prospective, randomized, double-blind, placebo-controlled study. *Minerva Anestesiol*. 2010;76:249-59.
414. Sirivella S, Gielchinsky I, Parsonnet V. Mannitol, furosemide, and dopamine infusion in postoperative renal failure complicating cardiac surgery. *Ann Thorac Surg*. 2000;69:501-6.
415. Tumlin JA, Finkel KW, Murray PT, et al. Fenoldopam mesylate in early acute tubular necrosis: a randomized, double-blind, placebo-controlled clinical trial. *Am J Kidney Dis*. 2005;46:26-34.
416. Vesely DL. Natriuretic peptides and acute renal failure. *Am J Physiol Renal Physiol*. 2003;285:F167-77.
417. Wang G, Bainbridge D, Martin J, et al. N-acetylcysteine in cardiac surgery: Do the benefits outweigh the risks? A meta-analytic reappraisal. *J Cardiothorac Vasc Anesth.* 2010;2:268-75.
418. Young EW, Diab A, Kirsh MM. Intravenous diltiazem and acute renal failure after cardiac operations. *Ann Thorac Surg*. 1998;65:1316-9.
419. Christenson JT, Cohen M, Ferguson JJI, et al. Trends in intraaortic balloon counterpulsation complications and outcomes in cardiac surgery. *Ann Thorac Surg*. 2002;74:1086-90.
420. Christenson JT, Simonet F, Badel P, et al. Optimal timing of preoperative intra-aortic balloon pump support in high-risk coronary patients. *Ann Thorac Surg*. 1999;68:934-9.
421. Christenson JT, Licker M, Kalangos A. The role of intra-aortic counterpulsation in high-risk OPCAB surgery: a prospective randomized study. *J Card Surg*. 2003;18:286-94.
422. Christenson JT, Schmuziger M, Simonet F. Effective surgical management of high-risk coronary patients using preoperative intra-aortic balloon counterpulsation therapy. *Cardiovasc Surg*. 2001;9:383-90.
423. Urban PM, Freedman RJ, Ohman EM, et al. In-hospital mortality associated with the use of intra-aortic balloon counterpulsation. *Am J Cardiol*. 2004;94:181-5.
424. Santa-Cruz RA, Cohen MG, Ohman EM. Aortic counterpulsation: a review of the hemodynamic effects and indications for use. *Catheter Cardiovasc Interv*. 2006;67:68-77.
425. Yau JM, Alexander JH, Hafley G, et al. Impact of perioperative myocardial infarction on angiographic and clinical outcomes following coronary artery bypass grafting (from PRoject of Ex-vivo Vein graft ENgineering via Transfection [PREVENT] IV). *Am J Cardiol*. 2008;102:546-51.
426. Koch CG, Li L, Duncan AI, et al. Transfusion in coronary artery bypass grafting is associated with reduced long-term survival. *Ann Thorac Surg*. 2006;81: 1650-7.
427. Surgenor SD, DeFoe GR, Fillinger MP, et al. Intraoperative red blood cell transfusion during coronary artery bypass graft surgery increases the risk of postoperative low-output heart failure. *Circulation*. 2006;114:I43-8.
428. van Straten AH, Bekker MW, Soliman Hamad MA, et al. Transfusion of red blood cells: the impact on short-term and long-term survival after coronary artery bypass grafting, a ten-year follow-up. *Interact Cardiovasc Thorac Surg*. 2010;10:37-42.
429. van Straten AH, Kats S, Bekker MW, et al. Risk factors for red blood cell transfusion after coronary artery bypass graft surgery. *J Cardiothorac Vasc Anesth*. 2010;24:413-7.
430. Daoud EG, Strickberger SA, Man KC, et al. Preoperative amiodarone as prophylaxis against atrial fibrillation after heart surgery. *N Engl J Med*. 1997; 337:1785-91.
431. Fergusson DA, Hebert PC, Mazer CD, et al. A comparison of aprotinin and lysine analogues in high-risk cardiac surgery [published correction appears in *N Engl J Med.* 2010;363:1290]. *N Engl J Med*. 2008;358:2319-31.
432. Greilich PE, Jessen ME, Satyanarayana N, et al. The effect of epsilon-aminocaproic acid and aprotinin on fibrinolysis and blood loss in patients undergoing primary, isolated coronary artery bypass surgery: a randomized, double-blind, placebo-controlled, noninferiority trial. *Anesth Analg*. 2009; 109:15-24.
433. Kikura M, Levy JH, Tanaka KA, et al. A double-blind, placebo-controlled trial of epsilon-aminocaproic acid for reducing blood loss in coronary artery bypass grafting surgery. *J Am Coll Surg*. 2006;202:216-22.
434. Mehr-Aein A, Sadeghi M, Madani-civi M. Does tranexamic acid reduce blood loss in off-pump coronary artery bypass? *Asian Cardiovasc Thorac Ann*. 2007; 15:285-9.
435. Mehr-Aein A, Davoodi S, Madani-civi M. Effects of tranexamic acid and autotransfusion in coronary artery bypass. *Asian Cardiovasc Thorac Ann.* 2007;15:49-53.
436. Murphy GJ, Mango E, Lucchetti V, et al. A randomized trial of tranexamic acid in combination with cell salvage plus a meta-analysis of randomized trials evaluating tranexamic acid in off-pump coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 2006;132:475-80, e1-8.
437. Santos AT, Kalil RA, Bauemann C, et al. A randomized, double-blind, and placebo-controlled study with tranexamic acid of bleeding and fibrinolytic activity after primary coronary artery bypass grafting. *Braz J Med Biol Res*. 2006;39:63-9.
438. Taghaddomi RJ, Mirzaee A, Attar AS, et al. Tranexamic acid reduces blood loss in off-pump coronary artery bypass surgery. *J Cardiothorac Vasc Anesth*. 2009; 23:312-5.
439. Paone G, Spencer T, Silverman NA. Blood conservation in coronary artery surgery. *Surgery.* 1994;116:672-7.
440. Nuttall GA, Oliver WC, Santrach PJ, et al. Efficacy of a simple intraoperative transfusion algorithm for nonerythrocyte component utilization after cardiopulmonary bypass. *Anesthesiology.* 2001;94:773-81.
441. Royston D, von Kier S. Reduced haemostatic factor transfusion using heparinase-modified thrombelastography during cardiopulmonary bypass. *Br J Anaesth*. 2001;86:575-8.
442. Avidan MS, Alcock EL, Da Fonseca J, et al. Comparison of structured use of routine laboratory tests or near-patient assessment with clinical judgement in the management of bleeding after cardiac surgery. *Br J Anaesth*. 2004;92:178-86.
443. Despotis GJ, Grishaber JE, Goodnough LT. The effect of an intraoperative treatment algorithm on physicians' transfusion practice in cardiac surgery. *Transfusion*. 1994;34:290-6.
444. Shore-Lesserson L, Manspeizer HE, DePerio M, et al. Thromboelastography-guided transfusion algorithm reduces transfusions in complex cardiac surgery. *Anesth Analg*. 1999;88:312-9.
445. Chu MW, Wilson SR, Novick RJ, et al. Does clopidogrel increase blood loss following coronary artery bypass surgery? *Ann Thorac Surg*. 2004;78:1536-41.
446. Englberger L, Faeh B, Berdat PA, et al. Impact of clopidogrel in coronary artery bypass grafting. *Eur J Cardiothorac Surg*. 2004;26:96-101.
447. Kapetanakis EI, Medlam DA, Petro KR, et al. Effect of clopidogrel premedication in off-pump cardiac surgery: are we forfeiting the benefits of reduced hemorrhagic sequelae? *Circulation*. 2006;113:1667-74.
448. Kim JH, Newby LK, Clare RM, et al. Clopidogrel use and bleeding after coronary artery bypass graft surgery. *Am Heart J*. 2008;156:886-92.
449. Maltais S, Perrault LP, Do QB. Effect of clopidogrel on bleeding and transfusions after off-pump coronary artery bypass graft surgery: impact of discontinuation prior to surgery. *Eur J Cardiothorac Surg*. 2008;34:127-31.

450. Vaccarino GN, Thierer J, Albertal M, et al. Impact of preoperative clopidogrel in off pump coronary artery bypass surgery: a propensity score analysis. *J Thorac Cardiovasc Surg*. 2009;137:309-13.
451. Yusuf S, Zhao F, Mehta SR, et al. Effects of clopidogrel in addition to aspirin in patients with acute coronary syndromes without ST-segment elevation [published corrections appear in *N Engl J Med.* 2011;345:1506; 2011;345:1716]. *N Engl J Med*. 2001;345:494-502.
452. Wiviott SD, Braunwald E, McCabe CH, et al., for the TRITON-TIMI 38 Investigators. Prasugrel versus clopidogrel in patients with acute coronary syndromes. *N Engl J Med.* 2007;357:2001-15.
453. Renda G, Di Pillo R, D'Alleva A, et al. Surgical bleeding after pre-operative unfractionated heparin and low molecular weight heparin for coronary bypass surgery. *Haematologica*. 2007;92:366-73.
454. McDonald SB, Renna M, Spitznagel EL, et al. Preoperative use of enoxaparin increases the risk of postoperative bleeding and re-exploration in cardiac surgery patients. *J Cardiothorac Vasc Anesth*. 2005;19:4-10.
455. Jones HU, Muhlestein JB, Jones KW, et al. Preoperative use of enoxaparin compared with unfractionated heparin increases the incidence of re-exploration for postoperative bleeding after open-heart surgery in patients who present with an acute coronary syndrome: clinical investigation and reports. *Circulation*. 2002; 106:I19-22.
456. Kincaid EH, Monroe ML, Saliba DL, et al. Effects of preoperative enoxaparin versus unfractionated heparin on bleeding indices in patients undergoing coronary artery bypass grafting. *Ann Thorac Surg*. 2003;76:124-8.
457. Medalion B, Frenkel G, Patachenko P, et al. Preoperative use of enoxaparin is not a risk factor for postoperative bleeding after coronary artery bypass surgery. *J Thorac Cardiovasc Surg*. 2003;126:1875-9.
458. Angelini GD, Taylor FC, Reeves BC, et al. Early and midterm outcome after off-pump and on-pump surgery in Beating Heart Against Cardioplegic Arrest Studies (BHACAS 1 and 2): a pooled analysis of two randomised controlled trials. *Lancet*. 2002;359:1194-9.
459. Cheng DC, Bainbridge D, Martin JE, et al. Does off-pump coronary artery bypass reduce mortality, morbidity, and resource utilization when compared with conventional coronary artery bypass? A meta-analysis of randomized trials. *Anesthesiology.* 2005;102:188-203.
460. Czerny M, Baumer H, Kilo J, et al. Complete revascularization in coronary artery bypass grafting with and without cardiopulmonary bypass. *Ann Thorac Surg*. 2001;71:165-9.
461. Khan NE, De Souza A, Mister R, et al. A randomized comparison of off-pump and on-pump multivessel coronary-artery bypass surgery. *N Engl J Med*. 2004; 350:21-8.
462. Puskas JD, Williams WH, Duke PG, et al. Off-pump coronary artery bypass grafting provides complete revascularization with reduced myocardial injury, transfusion requirements, and length of stay: a prospective randomized comparison of two hundred unselected patients undergoing off-pump versus conventional coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 2003;125:797-808.
463. Raja SG, Dreyfus GD. Impact of off-pump coronary artery bypass surgery on postoperative bleeding: current best available evidence. *J Card Surg*. 2006;21:35-41.
464. van Dijk D, Nierich AP, Jansen EW, et al. Early outcome after off-pump versus on-pump coronary bypass surgery: results from a randomized study. *Circulation*. 2001;104:1761-6.
465. Basso C, Maron BJ, Corrado D, et al. Clinical profile of congenital coronary artery anomalies with origin from the wrong aortic sinus leading to sudden death in young competitive athletes. *J Am Coll Cardiol*. 2000;35:1493-501.
466. Thomas D, Salloum J, Montalescot G, et al. Anomalous coronary arteries coursing between the aorta and pulmonary trunk: clinical indications for coronary artery bypass. *Eur Heart J*. 1991;12:832-4.
467. Krasuski RA, Magyar D, Hart S, et al. Long-term outcome and impact of surgery on adults with coronary arteries originating from the opposite coronary cusp. *Circulation*. 2011;123:154-62.
468. Frommelt PC, Sheridan DC, Berger S, et al. Ten-year experience with surgical unroofing of anomalous aortic origin of a coronary artery from the opposite sinus with an interarterial course. *J Thorac Cardiovasc Surg.* 2011 Mar 23 [E-pub ahead of print].
469. Hulzebos EH, Helders PJ, Favie NJ, et al. Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial. *JAMA*. 2006;296:1851-7.
470. Haeffener MP, Ferreira GM, Barreto SS, et al. Incentive spirometry with expiratory positive airway pressure reduces pulmonary complications, improves pulmonary function and 6-minute walk distance in patients undergoing coronary artery bypass graft surgery. *Am Heart J*. 2008;156:900e1-e8.
471. Zarbock A, Mueller E, Netzer S, et al. Prophylactic nasal continuous positive airway pressure following cardiac surgery protects from postoperative pulmonary complications: a prospective, randomized, controlled trial in 500 patients. *Chest*. 2009;135:1252-9.
472. Kofidis T, Baraki H, Singh H, et al. The minimized extracorporeal circulation system causes less inflammation and organ damage. *Perfusion*. 2008;23:147-51.
473. Liu SS, Block BM, Wu CL. Effects of perioperative central neuraxial analgesia on outcome after coronary artery bypass surgery: a meta-analysis. *Anesthesiology.* 2004;101:153-61.
474. Hemmelgarn BR, Southern D, Culleton BF, et al. Survival after coronary revascularization among patients with kidney disease. *Circulation*. 2004;110:1890-5.
475. Liu JY, Birkmeyer NJ, Sanders JH, et al. Risks of morbidity and mortality in dialysis patients undergoing coronary artery bypass surgery: Northern New England Cardiovascular Disease Study Group. *Circulation*. 2000;102:2973-7.
476. Filsoufi F, Aklog L, Adams DH, et al. Management of mild to moderate aortic stenosis at the time of coronary artery bypass grafting. *J Heart Valve Dis*. 2002; 11(Suppl 1):S45-9.
477. Smith WT IV, Ferguson TB Jr, Ryan T, et al. Should coronary artery bypass graft surgery patients with mild or moderate aortic stenosis undergo concomitant aortic valve replacement? A decision analysis approach to the surgical dilemma. *J Am Coll Cardiol*. 2004;44:1241-7.
478. Pereira JJ, Balaban K, Lauer MS, et al. Aortic valve replacement in patients with mild or moderate aortic stenosis and coronary bypass surgery. *Am J Med*. 2005; 118:735-42.
479. Gillinov AM, Garcia MJ. When is concomitant aortic valve replacement indicated in patients with mild to moderate stenosis undergoing coronary revascularization? *Curr Cardiol Rep*. 2005;7:101-4.
480. Gillinov AM, Wierup PN, Blackstone EH, et al. Is repair preferable to replacement for ischemic mitral regurgitation? *J Thorac Cardiovasc Surg*. 2001;122: 1125-41.
481. Aklog L, Filsoufi F, Flores KQ, et al. Does coronary artery bypass grafting alone correct moderate ischemic mitral regurgitation? *Circulation*. 2001;104:I68-75.
482. Trichon BH, Glower DD, Shaw LK, et al. Survival after coronary revascularization, with and without mitral valve surgery, in patients with ischemic mitral regurgitation. *Circulation*. 2003;108(Suppl 1):II103-10.
483. Fattouch K, Guccione F, Sampognaro R, et al. POINT: Efficacy of adding mitral valve restrictive annuloplasty to coronary artery bypass grafting in patients with moderate ischemic mitral valve regurgitation: a randomized trial. *J Thorac Cardiovasc Surg*. 2009;138:278-85.
484. Fattouch K, Sampognaro R, Speziale G, et al. Impact of moderate ischemic mitral regurgitation after isolated coronary artery bypass grafting. *Ann Thorac Surg*. 2010;90:1187-94.
485. Zoghbi W, Sarano M. Recommendations for the evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography. *J Am Soc of Echocardiography.* 2003;16:777-802.
486. Sergeant P, Blackstone E, Meyns B. Is return of angina after coronary artery bypass grafting immutable, can it be delayed, and is it important? *J Thorac Cardiovasc Surg*. 1998;116:440-53.

APPENDIX 1. Author relationships with industry and other entities (relevant)—2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery

Committee member	Employer/title	Consultant	Speaker's bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness	Voting recusals by section numbers*
L. David Hillis *(Chair)*	University of Texas Health Science Center at San Antonio—Professor and Chair of the Department of Medicine	None	None	None	None	None	None	None
Peter K. Smith *(Vice Chair)*	Duke University Medical Center: Private Diagnostic Clinic—Professor of Surgery; Chief of Thoracic Surgery	• Eli Lilly • Baxter BioSurgery	None	None	None	None	None	2.2.3 4.1 4.2 5.2.6
Jeffrey L. Anderson	Intermountain Medical Center—Associate Chief of Cardiology	• BMS/sanofi-aventis	None	None	• Toshiba‡ • Gilead Pharma • AstraZeneca	None	None	2.1.6 2.2.3 4.1 4.2 4.3 5.2.6
John A. Bittl	Ocala Heart Institute Munroe Regional Medical Center—Interventional Cardiologist	None	None	None	None	None	None	None
Charles R. Bridges	University of Pennsylvania Medical Center—Chief of Cardiothoracic Surgery	• Baxter BioSurgery‡ • Zymogenetics	• Bayer Pharmaceuticals	None	None	None	• Plaintiff, alleged mitral valve dysfunction, 2009 • Defendant, retinal artery occlusion (stroke) after CABG, 2009 • Defendant, timely insertion of IABP after CABG, 2009 • Defendant, timely transport after acute aortic dissection, 2009 • Plaintiff, unexpected intra-abdominal hemorrhage and death after AVR, 2009	2.2.3 4.1 4.2 5.2.6
John G. Byrne	Vanderbilt University Medical Center: Division of Cardiac Surgery—Chairman of Cardiac Surgery	None	None	None	None	None	None	None
Joaquin E. Cigarroa	Oregon Health and Science University—Associate Professor of Medicine	None	None	None	None	None	None	None

(Continued)

APPENDIX 1. Continued

Committee member	Employer/title	Consultant	Speaker's bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness	Voting recusals by section numbers*
Verdi J. DiSesa	John Hopkins Hospital, Division of Cardiac Surgery—Clinical Associate	None	None	None	None	None	None	None
Loren F. Hiratzka	Cardiac, Vascular and Thoracic Surgeons, Inc.—Medical Director of Cardiac Surgery	None	None	None	None	None	None	None
Adolph M. Hutter, Jr	Massachusetts General Hospital—Professor of Medicine	None	None	None	None	None	None	None
Michael E. Jessen	UT Southwestern Medical Center—Professor of Cardiothoracic Surgery	• Quest Medical‡	None	None	None	None	None	2.1.8
Ellen C. Keeley	University of Virginia—Associate Professor of Internal Medicine	None	None	None	None	None	None	None
Stephen J. Lahey	University of Connecticut—Professor and Chief of Cardiothoracic Surgery	None	None	None	None	None	• Defendant, mitral valve replacement, 2009	None
Richard A. Lange	University of Texas Health Science Center at San Antonio—Professor of Medicine	None	None	None	None	None	None	None
Martin J. London	University of California San Francisco, Veterans Affairs Medical Center—Professor of Clinical Anesthesia	None	None	None	None	None	None	None
Michael J. Mack	The Heart Hospital Baylor Plano—Cardiovascular Surgery, Medical Director	• Cordis • Marquett • Medtronic • Edwards Lifesciences‡	None	None	None	None	None	2.1.3 2.2.1 5.2.1.1 5.2.1.2
Manesh R. Patel	Duke University Medical Center—Associate Professor of Medicine	None	None	None	None	None	None	None
John D. Puskas	Emory University/Emory Healthcare—Chief of Cardiac Surgery	• Marquett • Medtronic	None	None	• Marquett† • Medtronic†	None	None	2.1.3 2.2.1 2.2.2
Joseph F. Sabik	Cleveland Clinic Foundation—Professor of Surgery	• Edwards Lifesciences • Medtronic	None	None	None	None	None	2.2.2 5.2.1.1 5.2.1.2
Ola Selnes	John Hopkins Hospital, Department of Neurology—Professor of Neurology	None	None	None	None	None	None	None
David M. Shahian	Massachusetts General Hospital—Professor of Surgery	None	None	None	None	None	None	None
Jeffrey C. Trost	John Hopkins School of Medicine—Assistant Professor of Medicine	None	None	None	• Toshiba†	None	None	2.1.7 3.5 4.10 4.10.1 4.10.2 4.10.3 5.2.1.1.1 5.2.1.1.2

(Continued)

APPENDIX 1. Continued

Committee member	Employer/title	Consultant	Speaker's bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness	Voting recusals by section numbers*
Michael D. Winniford	University of Mississippi Medical Center—Professor of Medicine	None	None	None	None	None	None	None

This table represents the relationships of committee members with industry and other entities that were determined to be relevant to this document. These relationships were reviewed and updated in conjunction with all meetings and/or conference calls of the writing committee during the document development process. The table does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of ≥5% of the voting stock or share of the business entity, or ownership of ≥$10,000 of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. Relationships that exist with no financial benefit are also included for the purpose of transparency. Relationships in this table are modest unless otherwise noted. According to the ACCF/AHA, a person has a *relevant* relationship IF: (a) The *relationship or interest* relates to the same or similar subject matter, intellectual property or asset, topic, or issue addressed in the *document*; or (b) the *company/entity* (with whom the relationship exists) makes a drug, drug class, or device addressed in the *document*, or makes a competing drug or device addressed in the *document*; or (c) the *person or a member of the person's household*, has a reasonable potential for financial, professional or other personal gain or loss as a result of the issues/content addressed in the *document*. *AVR,* Aortic valve replacement; *CABG,* coronary artery bypass graft surgery; and *IABP,* intra-aortic balloon pump. *Writing committee members are required to recuse themselves from voting on sections to which their specific relationships with industry and other entities may apply. Section numbers apply to the full-text guideline. †Significant relationship. ‡No financial benefit.

APPENDIX 2. Reviewer relationships with industry and other entitites (relevant)—2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery

Peer reviewer	Representation	Consultant	Speaker's bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
Robert Guyton	Official Reviewer—ACCF/AHA Task Force on Practice Guidelines	None	None	None	• Edwards Lifesciences	None	None
Jeffrey Jacobs	Official Reviewer—ACCF/AHA Task Force on Data Standards	None	None	None	None	None	None
L. Kristin Newby	Official Reviewer—AHA	• AstraZeneca	None	None	• Eli Lilly* • GlaxoSmithKline†	None	None
Eric D. Peterson	Official Reviewer—ACCF/AHA Task Force on Performance Measures	• AstraZeneca	None	None	• BMS/sanofi-aventis† • Eli Lilly†	None	None
Richard J. Shemin	Official Reviewer—AHA	• Edwards Lifesciences	None	None	None	None	None
Hector Ventura	Official Reviewer—ACCF Board of Governors	None	• Actelion • Gilead	None	None	None	None
Thad F. Waites	Official Reviewer—ACCF Board of Trustees	None	None	None	None	None	None
T. Bruce Ferguson, Jr	Organizational Reviewer—STS	None	None	None	None	None	None
Stephen E. Fremes	Organizational Reviewer—AATS	None	None	None	None	Merck	• Defendant, leaking thoracic aortic aneurysm, 2009 • Defendant, aortic dissection, 2009
Colleen G. Koch	Organizational Reviewer—SCA	None	None	None	None	None	None
Harold L. Lazar	Organizational Reviewer—AATS	None	None	None	None	None	None

(Continued)

APPENDIX 2. Continued

Peer reviewer	Representation	Consultant	Speaker's bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
Walter H. Merrill	Organizational Reviewer—STS	None	None	None	None	None	None
Stanton K. Shernan	Organizational Reviewer—SCA	None	• Philips Healthcare	None	None	None	• Plaintiff, communication of echocardiography results, 2010
Joseph S. Alpert	Content Reviewer	• Bayer • Sanofi-aventis	None	None	None	None	None
Robert M. Califf	Content Reviewer	• AstraZeneca • Daiichi-Sankyo • GlaxoSmithKline • Medtronic • Sanofi-aventis	None	None	• Eli Lilly† • Bayer	None	None
Robbin G. Cohen	Content Reviewer	None	None	None	None	None	• Defendant, death after minimally invasive heart surgery, 2011 • Defendant, diagnosis of aortic dissection, 2010 • Plaintiff, renal failure and Aprotinin, 2010
Mark A. Creager	Content Reviewer—ACCF/AHA Task Force on Practice Guidelines	• AstraZeneca • Genzyme • Merck • Roche • Vascutek	None	None	• Merck	None	• Plaintiff, Fasudil Development: *Asahi Pharma v Actelion*, 2010
Steven M. Ettinger	Content Reviewer—ACCF/AHA Task Force on Practice Guidelines	None	None	None	• Medtronic	None	None
David P. Faxon	Content Reviewer	• Sanofi-aventis	None	None	None	None	• Defendant, cath vascular access site complication, 2009
Kirsten E. Fleischmann	Content Reviewer	None	None	None	None	None	None
Lee Fleisher	Content Reviewer	None	None	None	• Pfizer	• AstraZeneca†	• Defendant, perioperative stroke, 2009
Anthony P. Furnary	Content Reviewer—ACCF Surgeons' Scientific Council	None	None	None	None	None	• Defendant, Bayer Corp. Trasylol litigation, 2009 to 2011
Valentin Fuster	Content Reviewer	None	None	None	None	None	None
John W. Hirshfeld, Jr	Content Reviewer	• GlaxoSmithKline	None	None	None	None	None
Judith S. Hochman	Content Reviewer—ACCF/AHA Task Force on Practice Guidelines	• Eli Lilly • GlaxoSmithKline	None	None	None	None	None
James L. Januzzi, Jr	Content Reviewer	• Roche	None	None	• Roche	None	None
Frederick G. Kushner	Content Reviewer—Vice Chair, 2012 STEMI Guideline Writing Committee	None	None	None	None	None	None

(Continued)

APPENDIX 2. Continued

Peer reviewer	Representation	Consultant	Speaker's bureau	Ownership/ partnership/ principal	Personal research	Institutional, organizational, or other financial benefit	Expert witness
Glenn Levine	Content Reviewer—Chair, 2011 PCI Guideline Writing Committee	None	None	None	None	None	None
Donald Likosky	Content Reviewer	None	None	None	• Maquet† • Medtronic†	None	None
James J. Livesay	Content Reviewer—Southern Thoracic Surgical Association	None	None	None	None	None	• Defendant, acute aortic dissection, 2011 • Defendant, cardiac mortality review, 2010 • Defendant, heparin induced thrombocytopenia, 2010
Bruce W. Lytle	Content Reviewer—2004 CABG Guideline Writing Committee	None	None	None	None	None	None
Robert A. Marlow	Content Reviewer—2004 CABG Guideline Writing Committee	None	None	None	None	None	None
Rick A. Nishimura	Content Reviewer—ACCF Board of Trustees	None	None	None	None	None	None
Patrick O'Gara	Content Reviewer—Chair, 2012 STEMI Guideline Writing Committee	None	None	None	None	None	None
E. Magnus Ohman	Content Reviewer—ACCF/AHA Task Force on Practice Guidelines	• AstraZeneca • Bristol-Myers Squibb • Boehringer Ingelheim • Gilead Sciences • Merck • Pozen • Sanofi-aventis	• Boehringer Ingelheim • Gilead Sciences	None	• Daiichi-Sankyo • Datascope • Eli Lilly	None	None
John D. Rutherford	Content Reviewer	None	None	None	None	None	None
George A. Stouffer	Content Reviewer	None	None	None	None	None	• Defendant, review of malpractice claim, 2010
Mathew Williams	Content Reviewer—ACCF Interventional Scientific Council	• Edwards Lifesciences • Medtronic	None	None	None	None	None

This table represents the relationships of reviewers with industry and other entities that were disclosed at the time of peer review and determined to be relevant. It does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of ≥5% of the voting stock or share of the business entity, or ownership of ≥$10,000 of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. A relationship is considered to be modest if it is less than significant under the preceding definition. Relationships that exist with no financial benefit are also included for the purpose of transparency. Relationships in this table are modest unless otherwise noted. Names are listed in alphabetical order within each category of review. According to the ACCF/AHA, a person has a *relevant* relationship IF: (a) The *relationship or interest* relates to the same or similar subject matter, intellectual property or asset, topic, or issue addressed in the *document*; or (b) the *company/entity* (with whom the relationship exists) makes a drug, drug class, or device addressed in the *document*, or makes a competing drug or device addressed in the *document*; or (c) the *person or a member of the person's household*, has a reasonable potential for financial, professional or other personal gain or loss as a result of the issues/content addressed in the *document*. *AATS,* American Association for Thoracic Surgery; *ACCF,* American College of Cardiology Foundation; *AHA,* American Heart Association; *CABG,* coronary artery bypass graft surgery; *PCI,* percutaneous coronary intervention; *SCA,* Society of Cardiovascular Anesthesiologists; *STEMI,* ST-elevation myocardial infarction; *STS,* Society of Thoracic Surgeons. *No financial benefit. †Significant relationship.