# 2021 ACC/AHA/AATS/STS/SCAI Guideline for Coronary Artery Revascularization

Endorsed by the Society for Cardiovascular Angiography and Interventions

# Citation

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# Top 10 Take-Home Messages

## 2021 Guideline for Coronary Artery Revascularization

# Top 10 Take Home Messages

1. Treatment decisions with regard to coronary revascularization in patients with coronary artery disease should be based on clinical indications, regardless of sex, race, or ethnicity, because there is no evidence that some patients benefit less than others, and efforts to reduce disparities of care are warranted.

# Top 10 Take Home Messages

2. In patients being considered for coronary revascularization for whom the optimal treatment strategy is unclear, a multidisciplinary Heart Team approach is recommended. Treatment decisions should be patient centered, incorporate patient preferences and goals, and include shared decision-making.

# Top 10 Take Home Messages

3. For patients with significant left main disease, surgical revascularization is indicated to improve survival relative to that likely to be achieved with medical therapy. Percutaneous revascularization is a reasonable option to improve survival, compared with medical therapy, in selected patients with low to medium anatomic complexity of coronary artery disease and left main disease that is equally suitable for surgical or percutaneous revascularization.

# Top 10 Take Home Messages

4. Updated evidence from contemporary trials supplement older evidence with regard to mortality benefit of revascularization in patients with stable ischemic heart disease, normal left ventricular ejection fraction, and triple-vessel coronary artery disease. Surgical revascularization may be reasonable to improve survival. A survival benefit with percutaneous revascularization is uncertain. Revascularization decisions are based on consideration of disease complexity, technical feasibility of treatment, and a Heart Team discussion.

# Top 10 Take Home Messages

5. The use of a radial artery as a surgical revascularization conduit is preferred to the use of a saphenous vein conduit to bypass the second most important target vessel with significant stenosis after the left anterior descending coronary artery. Benefits include superior patency, reduced adverse cardiac events, and improved survival.

# Top 10 Take Home Messages

6. Radial artery access is recommended in patients undergoing percutaneous intervention who have acute coronary syndromes or stable ischemic heart disease, to reduce bleeding and vascular complications compared with a femoral approach. Patients with acute coronary syndromes also benefit from a reduction in mortality rate with this approach.

# Top 10 Take Home Messages

7. A short duration of dual antiplatelet therapy after percutaneous revascularization in patients with stable ischemic heart disease is reasonable to reduce the risk of bleeding events. After consideration of recurrent ischemia and bleeding risks, select patients may safely transition to P2Y12 inhibitor monotherapy and stop aspirin after 1 to 3 months of dual antiplatelet therapy.

# Top 10 Take Home Messages

8. Staged percutaneous intervention (while in hospital or after discharge) of a significantly stenosed non-culprit artery in patients presenting with an ST-segment–elevation myocardial infarction is recommended in select patients to improve outcomes. Percutaneous intervention of the non-culprit artery at the time of primary percutaneous coronary intervention is less clear and may be considered in stable patients with uncomplicated revascularization of the culprit artery, low-complexity non-culprit artery disease, and normal renal function. In contrast, percutaneous intervention of the non-culprit artery can be harmful in patients in cardiogenic shock.

# Top 10 Take Home Messages

9. Revascularization decisions in patients with diabetes and multivessel coronary artery disease are optimized by the use of a Heart Team approach. Patients with diabetes who have triple-vessel disease should undergo surgical revascularization; percutaneous coronary intervention may be considered if they are poor candidates for surgery.

# Top 10 Take Home Messages

10. Treatment decisions for patients undergoing surgical revascularization of coronary artery disease should include the calculation of a patient's surgical risk with the Society of Thoracic Surgeons score. The usefulness of the SYNTAX score calculation in treatment decisions is less clear because of the interobserver variability in its calculation and its absence of clinical variables.

# Table 2. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated May 2019)

| CLASS (STRENGTH) OF RECOMMENDATION | |
|---|---|
| **CLASS 1 (STRONG)** | **Benefit >>> Risk** |
| **Suggested phrases for writing recommendations:**<br>• Is recommended<br>• Is indicated/useful/effective/beneficial<br>• Should be performed/administered/other<br>• Comparative-Effectiveness Phrases†:<br>– Treatment/strategy A is recommended/indicated in preference to treatment B<br>– Treatment A should be chosen over treatment B | |
| **CLASS 2a (MODERATE)** | **Benefit >> Risk** |
| **Suggested phrases for writing recommendations:**<br>• Is reasonable<br>• Can be useful/effective/beneficial<br>• Comparative-Effectiveness Phrases†:<br>– Treatment/strategy A is probably recommended/indicated in preference to treatment B<br>– It is reasonable to choose treatment A over treatment B | |
| **CLASS 2b (WEAK)** | **Benefit ≥ Risk** |
| **Suggested phrases for writing recommendations:**<br>• May/might be reasonable<br>• May/might be considered<br>• Usefulness/effectiveness is unknown/unclear/uncertain or not well-established | |
| **CLASS 3: No Benefit (MODERATE)**<br>**(Generally, LOE A or B use only)** | **Benefit = Risk** |
| **Suggested phrases for writing recommendations:**<br>• Is not recommended<br>• Is not indicated/useful/effective/beneficial<br>• Should not be performed/administered/other | |
| **Class 3: Harm (STRONG)** | **Risk > Benefit** |
| **Suggested phrases for writing recommendations:**<br>• Potentially harmful<br>• Causes harm<br>• Associated with excess morbidity/mortality<br>• Should not be performed/administered/other | |

| LEVEL (QUALITY) OF EVIDENCE‡ | |
|---|---|
| **LEVEL A** | |
| • High-quality evidence‡ from more than 1 RCT<br>• Meta-analyses of high-quality RCTs<br>• One or more RCTs corroborated by high-quality registry studies | |
| **LEVEL B-R** | **(Randomized)** |
| • Moderate-quality evidence‡ from 1 or more RCTs<br>• Meta-analyses of moderate-quality RCTs | |
| **LEVEL B-NR** | **(Nonrandomized)** |
| • Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies<br>• Meta-analyses of such studies | |
| **LEVEL C-LD** | **(Limited Data)** |
| • Randomized or nonrandomized observational or registry studies with limitations of design or execution<br>• Meta-analyses of such studies<br>• Physiological or mechanistic studies in human subjects | |
| **LEVEL C-EO** | **(Expert Opinion)** |
| • Consensus of expert opinion based on clinical experience | |

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

# Improving Equity of Care in Revascularization and Shared Decision-Making

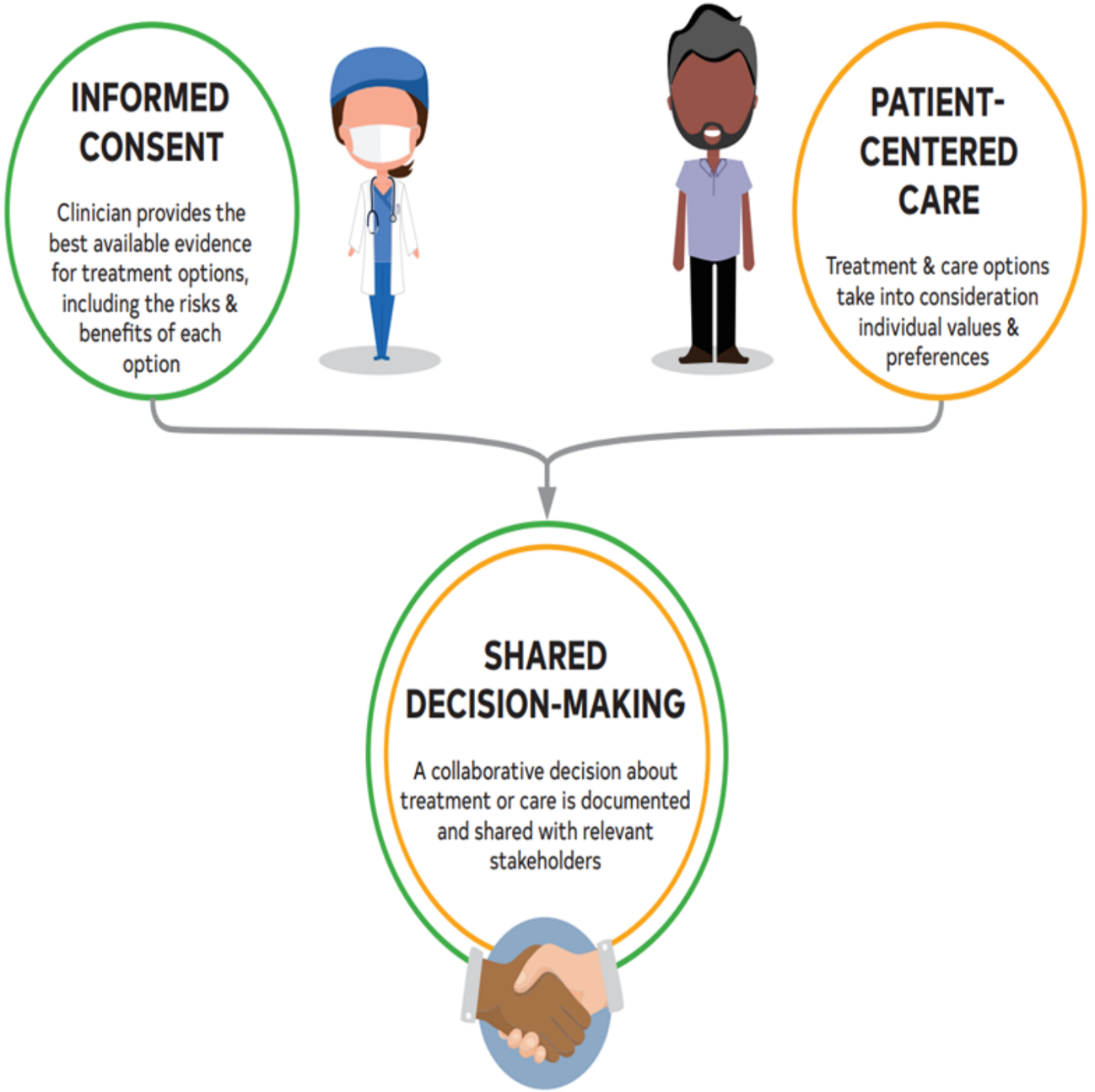
# Improving Equity of Care in Revascularization

| Recommendation to Improve Equity of Care in Revascularization<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 1. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **1** | **B-NR** | **1. In patients who require coronary revascularization, treatment decisions should be based on clinical indication, regardless of sex, or race or ethnicity, and efforts to reduce disparities of care are warranted.** |

# Shared Decision-Making and Informed Consent

| Recommendations for Shared Decision-Making and Informed Consent | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **C-LD** | **1. In patients undergoing revascularization, decisions should be patient centered—that is, considerate of the patient's preferences and goals, cultural beliefs, health literacy, and social determinants of health—and made in collaboration with the patient's support system.** |
| **1** | **C-LD** | **2. In patients undergoing coronary angiography or revascularization, adequate information about benefits, risks, therapeutic consequences, and potential alternatives in the performance of percutaneous and surgical myocardial revascularization should be given, when feasible, with sufficient time for informed decision-making to improve clinical outcomes.** |

Figure 1. Shared decision-making algorithm.



# Table 4. Ideal Components of the Shared Decision-Making and Informed Consent Process

| | **Patient-Centered Care** |
|---|---|
| | Assess a patient's ability to understand complex health information |
| | Seek support of family/others |
| | Elicit and respect cultural, racial, ethnic, or religious preferences and values |
| | Evaluate social determinants of health (education, income, access to health care) |
| | Improve telephone/telemedicine access |
| | Discuss treatment alternatives and how each affects the patient's quality of life |

# Table 4. Ideal Components of the Shared Decision-Making and Informed Consent Process (con't.)

| | **Shared Decision-Making** |
|---|---|
| | Encourage questions and explain the patient's role in the decision-making partnership |
| | Clearly and accurately communicate the potential risks and benefits of a particular procedure and alternative treatments |
| | Ensure that patients have a key role in deciding what revascularization approach is appropriate |
| | Use shared decision aids:<br>• Alphabetical List of Decision Aids by Health Topic, Ottawa Hospital Research Institute (https://decisionaid.ohri.ca/implement.html) (27)<br>• SHARE Approach Curriculum Tools, Agency for Healthcare Research and Quality (https://www.ahrq.gov/health-literacy/curriculum-tools/shareddecisionmaking/tools/tool-1/index.html) (28) |
| | Spend sufficient time to engage in shared decision-making; allow for a second opinion |
| | Work with a chaplain, social worker, or other team members to facilitate shared decision-making |
| | Encourage patients to share their fears, stress, or other emotions, and address appropriately |
| | Negotiate decision in partnership with the patient and family members |
| | Respect patient's autonomy to decline recommended treatment |

# Table 4. Ideal Components of the Shared Decision-Making and Informed Consent Process (con't.)

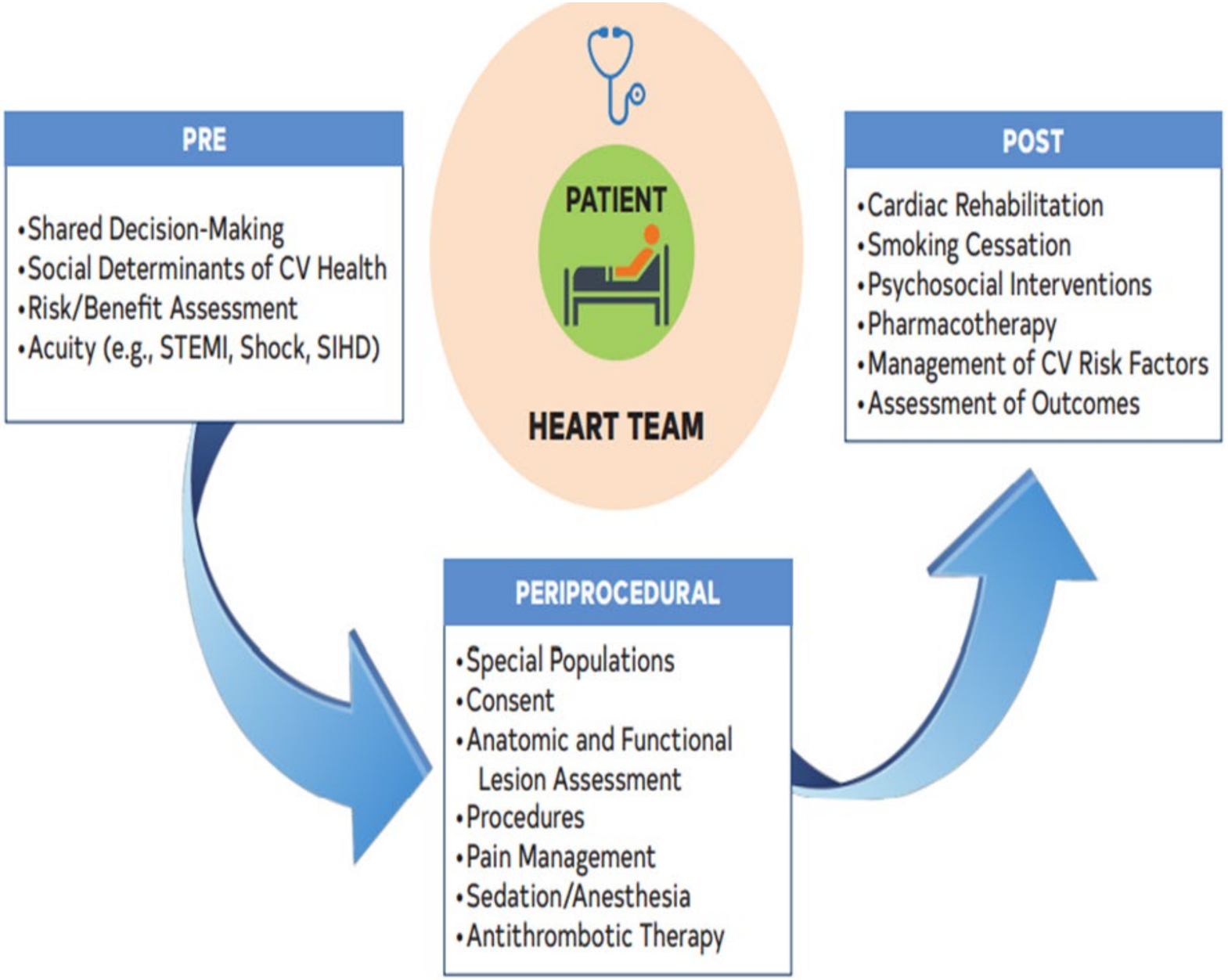
| | Consent Procedures |
|---|---|
| | Use plain language, avoiding jargon, and adopt the patient's words; integrate pictures to teach |
| | Document teach-back of patient's knowledge and understanding |
| | Conduct conversations with a trained interpreter, as needed |
| | Provide patient-specific short- and long-term risks, benefits, and alternative treatments |
| | Provide unbiased, evidence-based, reliable, accessible, and relevant information to patient |
| | Discuss specific risks and benefits with regard to survival, relief of angina, quality of life, and potential additional intervention, as well as uncertainties associated with different treatment strategies |
| | Provide patient time to reflect on the trade-offs imposed by the outcome estimates |
| | Provide information on the level of operator expertise, volume of the facility, and local results in the performance of coronary revascularization options |
| | Clearly inform of the need for continued medical therapy and lifestyle modifications |

# Preprocedural Assessment and the Heart Team

# The Heart Team

| Recommendation for the Heart Team<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 2. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **1** | **B-NR** | **1. In patients for whom the optimal treatment strategy is unclear, a Heart Team approach that includes representatives from interventional cardiology, cardiac surgery, and clinical cardiology is recommended to improve patient outcomes.** |

# Figure 2. Phases of patient-centric care in the treatment of coronary artery disease.




CV indicates cardiovascular; SIHD, stable ischemic heart disease; and STEMI, ST-segment elevation myocardial infarction.

# Table 5. Factors for Consideration by the Heart Team

| Coronary Anatomy |
| --- |
| • Left main disease<br>• Multivessel disease<br>• High anatomic complexity (i.e., bifurcation disease, high SYNTAX score) |
| **Comorbidities** |
| • Diabetes<br>• Systolic dysfunction<br>• Coagulopathy<br>• Valvular heart disease<br>• Frailty<br>• Malignant neoplasm<br>• End-stage renal disease<br>• Chronic obstructive pulmonary disease<br>• Immunosuppression<br>• Debilitating neurological disorders<br>• Liver disease/cirrhosis<br>• Prior CVA<br>• Calcified/Porcelain aorta<br>• Aortic Aneurysm |

# Table 5. Factors for Consideration by the Heart Team (con't.)

| Procedural Factors |
| --- |
| • Local and regional outcomes<br>• Access site for PCI<br>• Surgical risk<br>• PCI risk |
| **Patient Factors** |
| • Unstable presentation or shock<br>• Patient preferences<br>• Inability or unwillingness to adhere to DAPT<br>• Patient social support<br>• Religious beliefs<br>• Patient education, knowledge, and understanding |

*DAPT indicates dual antiplatelet therapy; PCI, percutaneous coronary intervention; and SYNTAX, Synergy Between PCI With TAXUS and Cardiac Surgery.*

# Predicting Patient Risk of Death With CABG

| Recommendation for Predicting Patient Risk of Death With CABG<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplements 3. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **1** | **B-NR** | **1. In patients who are being considered for CABG, calculation of the Society of Thoracic Surgeons (STS) risk score is recommended to help stratify patient risk.** |

# Table 6. Assessment of Risk Factors Not Quantified in the STS Score

| Risk Factor | Assessment Tool |
|---|---|
| Cirrhosis | Model for End-Stage Liver Disease (MELD) |
| Frailty | Gait speed |
| Malnutrition | Malnutrition Universal Screening Tool (MUST) |

*STS indicates Society of Thoracic Surgeons.*

# Defining Lesion Severity

# Defining Coronary Artery Lesion Complexity: Calculation of the SYNTAX (Synergy Between PCI With TAXUS and Cardiac Surgery) Score

| Recommendation for Defining Coronary Artery Lesion Complexity: Calculation of the SYNTAX Score<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 4. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2b** | **B-NR** | **1. In patients with multivessel CAD, an assessment of CAD complexity, such as the SYNTAX score, may be useful to guide revascularization.** |

# Table 7. Angiographic Features Contributing to Increasing Complexity of CAD

| |
|---|
| Multivessel disease |
| Left main or proximal LAD artery lesion |
| Chronic total occlusion |
| Trifurcation lesion |
| Complex bifurcation lesion |
| Heavy calcification |
| Severe tortuosity |
| Aorto-ostial stenosis |
| Diffusely diseased and narrowed segments distal to the lesion |
| Thrombotic lesion |
| Lesion length >20 mm |

*CAD indicates coronary artery disease; and LAD, left anterior descending.*

# Use of Coronary Physiology to Guide Revascularization With PCI

| Recommendations for the Use of Coronary Physiology to Guide Revascularization With PCI<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 5. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients with angina or an anginal equivalent, undocumented ischemia, and angiographically intermediate stenoses, the use of fractional flow reserve (FFR) or instantaneous wave-free ratio (iFR) is recommended to guide the decision to proceed with PCI.** |
| **3: No benefit** | **B-R** | **2. In stable patients with angiographically intermediate stenoses and FFR >0.80 or iFR >0.89, PCI should not be performed.** |

# Intravascular Ultrasound to Assess Lesion Severity

| Recommendation for Intravascular Ultrasound to Assess Lesion Severity<br>Referenced studies that support the recommendation are summarized in Online Data Supplement 6. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2a** | **B-NR** | **1. In patients with intermediate stenosis of the left main artery, intravascular ultrasound (IVUS) is reasonable to help define lesion severity.** |

# Revascularization in STEMI

# Revascularization of the Infarct Artery in Patients With STEMI

| Recommendations for Revascularization of the Infarct Artery in Patients with STEMI<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 7. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients with STEMI and ischemic symptoms for <12 hours, PCI should be performed to improve survival.** |
| **1** | **B-R** | **2. In patients with STEMI and cardiogenic shock or hemodynamic instability, PCI or CABG (when PCI is not feasible) is indicated to improve survival, irrespective of the time delay from MI onset.** |

# Revascularization of the Infarct Artery in Patients With STEMI (con't.)

| | | |
|---|---|---|
| 1 | B-NR | 3. In patients with STEMI who have mechanical complications (e.g., ventricular septal rupture, mitral valve insufficiency because of papillary muscle infarction or rupture, or free wall rupture), CABG is recommended at the time of surgery, with the goal of improving survival. |
| 1 | C--LD | 4. In patients with STEMI and evidence of failed reperfusion after fibrinolytic therapy, rescue PCI of the infarct artery should be performed to improve clinical outcomes. |

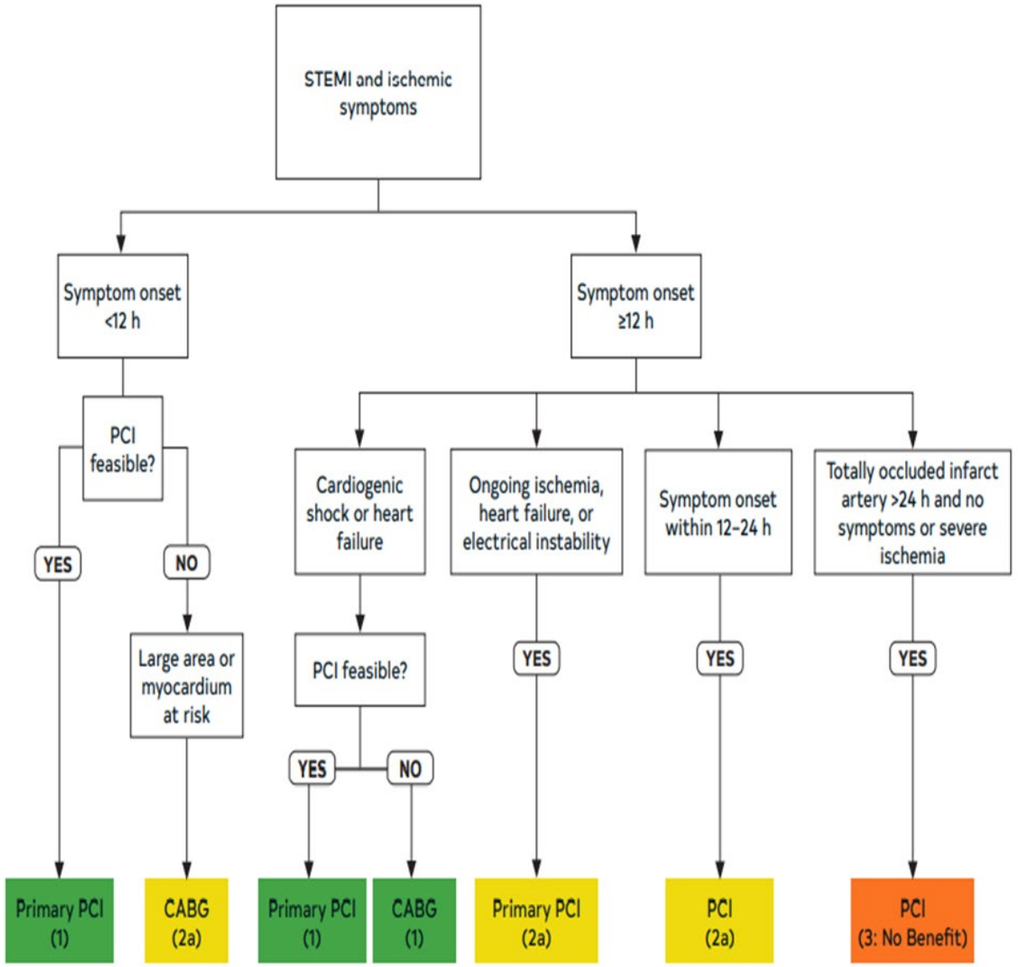
# Revascularization of the Infarct Artery in Patients With STEMI (con't.)

| | | |
|---|---|---|
| 2a | B-R | 5. In patients with STEMI who are treated with fibrinolytic therapy, angiography within 3 to 24 hours with the intent to perform PCI is reasonable to improve clinical outcomes. |
| 2a | B-NR | 6. In patients with STEMI who are stable and presenting 12 to 24 hours after symptom onset, PCI is reasonable to improve clinical outcomes. |
| 2a | B-NR | 7. In patients with STEMI in whom PCI is not feasible or successful, with a large area of myocardium at risk, emergency or urgent CABG can be effective as a reperfusion modality to improve clinical outcomes. |

# Revascularization of the Infarct Artery in Patients With STEMI (con't.)

| | | |
|---|---|---|
| **2a** | **C-EO** | **8. In patients with STEMI complicated by ongoing ischemia, acute severe heart failure, or life-threatening arrhythmia, PCI can be beneficial to improve clinical outcomes, irrespective of time delay from MI onset.** |
| **3: No Benefit** | **B-R** | **9. In asymptomatic stable patients with STEMI who have a totally occluded infarct artery >24 hours after symptom onset and are without evidence of severe ischemia, PCI should not be performed (25, 26).** |
| **3: Harm** | **C-EO** | **10. In patients with STEMI, emergency CABG should not be performed after failed primary PCI:**<br>• **In the absence of ischemia or a large area of myocardium at risk, or**<br>• **If surgical revascularization is not feasible because of a no-reflow state or poor distal targets.** |

# Figure 3. Indications for revascularization in STEMI (patients without fibrinolytics).




Colors correspond to Table 2.

CABG indicates coronary artery bypass graft; PCI, percutaneous coronary intervention; and STEMI, ST-segment elevation myocardial infarction.

# Revascularization of the Non-Infarct Artery in Patients With STEMI

| Recommendations for Revascularization of the Non-Infarct Artery in Patients With STEMI<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 8. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In selected hemodynamically stable patients with STEMI and multivessel disease, after successful primary PCI, staged PCI of a significant non-infarct artery stenosis is recommended to reduce the risk of death or MI.** |

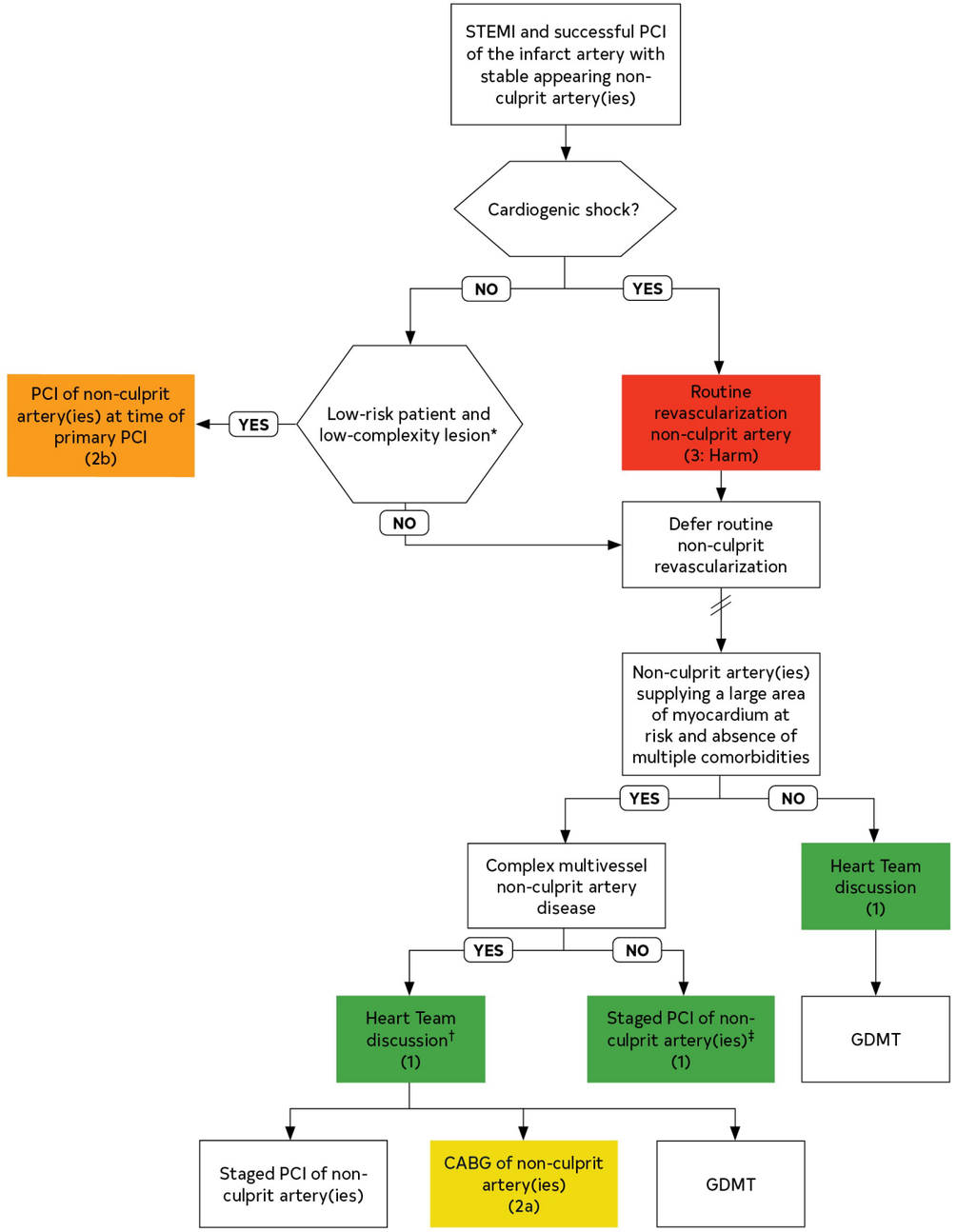
# Revascularization of the Non-Infarct Artery in Patients With STEMI (con't.)

| | | |
|---|---|---|
| 2a | C-EO | 2. In selected patients with STEMI with complex multivessel non-infarct artery disease, after successful primary PCI, elective CABG is reasonable to reduce the risk of cardiac events. |
| 2b | B-R | 3. In selected hemodynamically stable patients with STEMI and low-complexity multivessel disease, PCI of a non-infarct artery stenosis may be considered at the time of primary PCI to reduce cardiac event rates. |
| 3: Harm | B-R | 4. In patients with STEMI complicated by cardiogenic shock, routine PCI of a non-infarct artery at the time of primary PCI should not be performed because of the higher risk of death or renal failure. |

# Figure 4. Revascularization of non–infarct-related coronary artery lesions in patients with STEMI.

Colors correspond to Table 2.

CABG indicates coronary artery bypass graft; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.




*Normal blood pressure and heart rate left ventricular end-diastolic pressure <20 mmHg, no chronic renal insufficiency or acute kidney injury, and expected total contrast volume <3× glomerular filtration rate, simple lesion anatomy.

†In making the decision about the need for and mode of revascularization the Heart Team should consider the suitability of the non-culprit artery for PCI, the coronary complexity and the risk of revascularization, the extent of myocardium at risk, and patient comorbidities, including life expectancy or other significant patient comorbidities, such as chronic renal insufficiency or acute kidney injury.

‡ Staged PCI can be performed in hospital or after discharge, up to 45 days post MI.

Symbol denotes time elapsed before proceeding to the next procedure.

# Table 8. Patient Clinical Status Definitions to Guide Revascularization

| | |
|---|---|
| **Elective** | The patient's cardiac function has been stable in the days or weeks before intervention (whether surgical or procedural). The intervention could be deferred without increased risk of compromise to cardiac outcome. |
| **Urgent** | Intervention is required during the same hospitalization to minimize chance of further clinical deterioration. Examples include, but are not limited to, worsening sudden chest pain, heart failure, acute myocardial infarction, anatomy, intra-aortic balloon pump, unstable angina, with intravenous nitroglycerin, or rest angina. |

# Table 8. Patient Clinical Status Definitions to Guide Revascularization (con't.)

| | |
|---|---|
| **Emergency** | Patients requiring emergency intervention will have ongoing, refractory (difficult, complicated, and/or unmanageable), unrelenting cardiac compromise, with or without hemodynamic instability, and not responsive to any form of therapy except cardiac intervention. An emergency intervention is one in which there should be no delay in providing operative intervention. |
| **Emergency/salvage** | Patients requiring emergency/salvage intervention are those who require cardiopulmonary resuscitation en route to the operating room, or procedure room, before induction of anesthesia or who require extracorporeal membrane oxygenation to maintain life. |

# Revascularization in Non–ST-Segment–Elevation Acute Coronary Syndrome (NSTE-ACS)

# Coronary Angiography and Revascularization in Patients with NSTE-ACS

| Recommendations for Coronary Angiography and Revascularization in Patients With NSTE-ACS<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 9. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients with NSTE-ACS who are at elevated risk of recurrent ischemic events and are appropriate candidates for revascularization, an invasive strategy with the intent to proceed with revascularization is indicated to reduce cardiovascular events.** |
| **1** | **B-R** | **2. In patients with NSTE-ACS and cardiogenic shock who are appropriate candidates for revascularization, emergency revascularization is recommended to reduce risk of death.** |

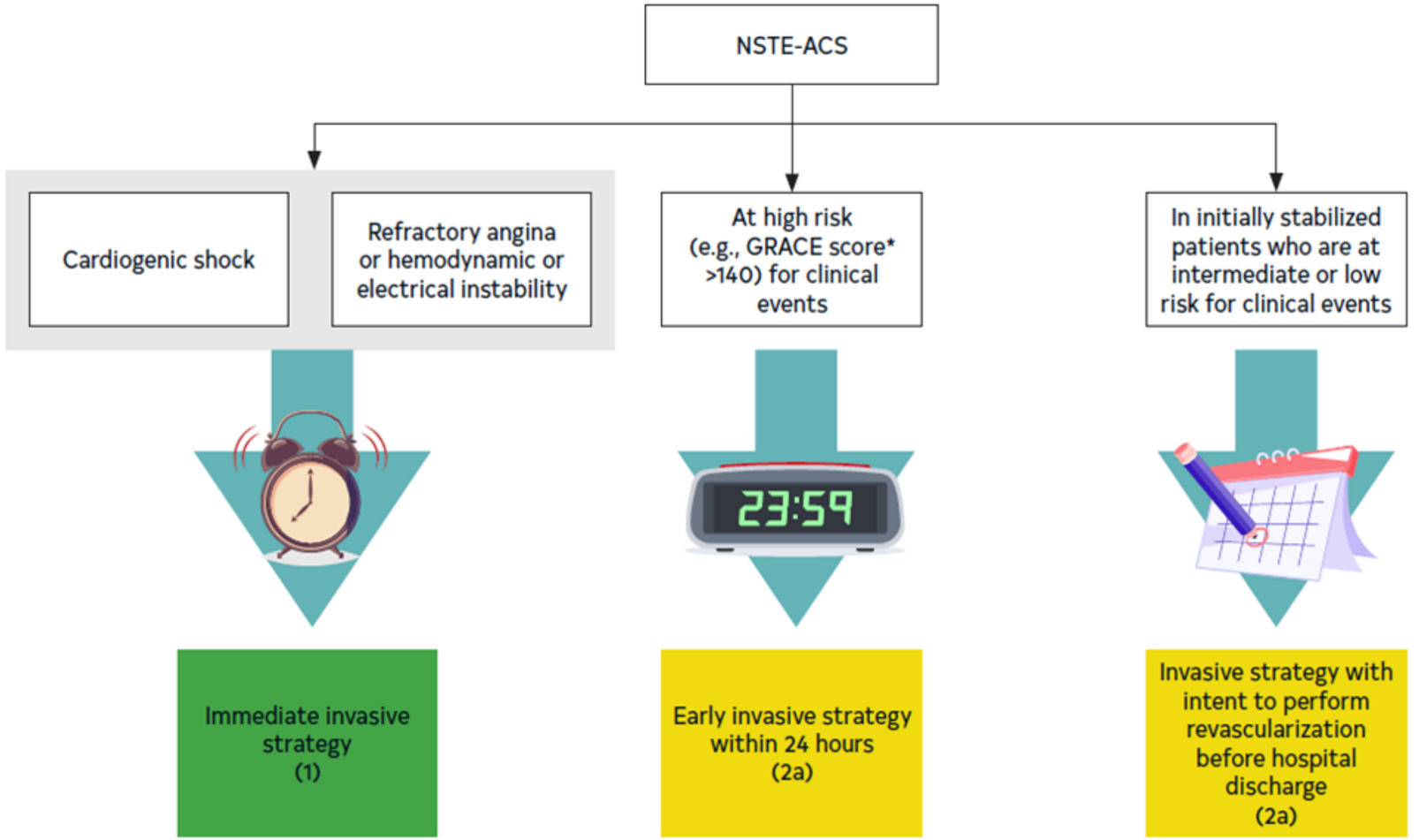
# Coronary Angiography and Revascularization in Patients with NSTE-ACS (con't.)

| | | |
|---|---|---|
| 1 | C-LD | 3. In appropriate patients with NSTE-ACS who have refractory angina or hemodynamic or electrical instability, an immediate invasive strategy with intent to perform revascularization is indicated to improve outcomes. |
| 2a | B-R | 4. In patients with NSTE-ACS who are initially stabilized and are at high risk of clinical events, it is reasonable to choose an early invasive strategy (within 24 hours) over a delayed invasive strategy to improve outcomes. |
| 2a | B-R | 5. In patients with NSTE-ACS who are initially stabilized and are at intermediate or low risk of clinical events, an invasive strategy with intent to perform revascularization is reasonable before hospital discharge to improve outcomes. |

# Coronary Angiography and Revascularization in Patients with NSTE-ACS (con't.)

| | | |
|---|---|---|
| **2a** | **B-NR** | **6. In patients with NSTE-ACS who have failed PCI and have ongoing ischemia, hemodynamic compromise, or threatened occlusion of an artery with substantial myocardium at risk, who are appropriate candidates for CABG, emergency CABG is reasonable.** |
| **3: Harm** | **B-R** | **7. In patients with NSTE-ACS who present in cardiogenic shock, routine multivessel PCI of non-culprit lesions in the same setting should not be performed.** |

# Figure 5. Recommendations for the timing of invasive strategy in patients with NSTE-ACS.




Colors correspond to Table 2.

NSTE-ACS indicates non–ST-segment–elevation acute coro syndrome.

# Revascularization in SIHD

# Revascularization to Improve Survival in SIHD Compared With Medical Therapy

| Recommendations for Revascularization to Improve Survival in SIHD Compared With Medical Therapy<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 10. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| | | **Left ventricular dysfunction and multivessel CAD** |
| **1** | **B-R** | **1. In patients with SIHD and multivessel CAD appropriate for CABG with severe left ventricular systolic dysfunction (left ventricular ejection fraction <35%), CABG is recommended to improve survival.** |
| **2a** | **B-NR** | **2. In selected patients with SIHD and multivessel CAD appropriate for CABG and mild-to-moderate left ventricular systolic dysfunction (ejection fraction 35%–50%), CABG (to include a left internal mammary artery [LIMA] graft to the LAD) is reasonable to improve survival.** |

# Revascularization to Improve Survival in SIHD Compared With Medical Therapy (con't.)

| Left main CAD | | |
|---|---|---|
| 1 | B-R | 3. In patients with SIHD and significant left main stenosis, CABG is recommended to improve survival. |
| 2a | B-NR | 4. In selected patients with SIHD and significant left main stenosis for whom PCI can provide equivalent revascularization to that possible with CABG, PCI is reasonable to improve survival. |

# Revascularization to Improve Survival in SIHD Compared With Medical Therapy (con't.)

| Multivessel CAD | | |
|---|---|---|
| 2b | B-R | 5. In patients with SIHD, normal ejection fraction, significant stenosis in 3 major coronary arteries (with or without proximal LAD), and anatomy suitable for CABG, CABG may be reasonable to improve survival. |
| 2b | B-R | 6. In patients with SIHD, normal ejection fraction, significant stenosis in 3 major coronary arteries (with or without proximal LAD), and anatomy suitable for PCI, the usefulness of PCI to improve survival is uncertain. |

# Revascularization to Improve Survival in SIHD Compared With Medical Therapy (con't.)

| | | |
|---|---|---|
| **Stenosis in the proximal LAD artery** | | |
| **2b** | **B-R** | **7. In patients with SIHD, normal left ventricular ejection fraction, and significant stenosis in the proximal LAD, the usefulness of coronary revascularization to improve survival is uncertain.** |
| **Single- or double-vessel disease not involving the proximal LAD** | | |
| **3: No Benefit** | **B-R** | **8. In patients with SIHD, normal left ventricular ejection fraction, and 1- or 2-vessel CAD not involving the proximal LAD, coronary revascularization is not recommended to improve survival.** |

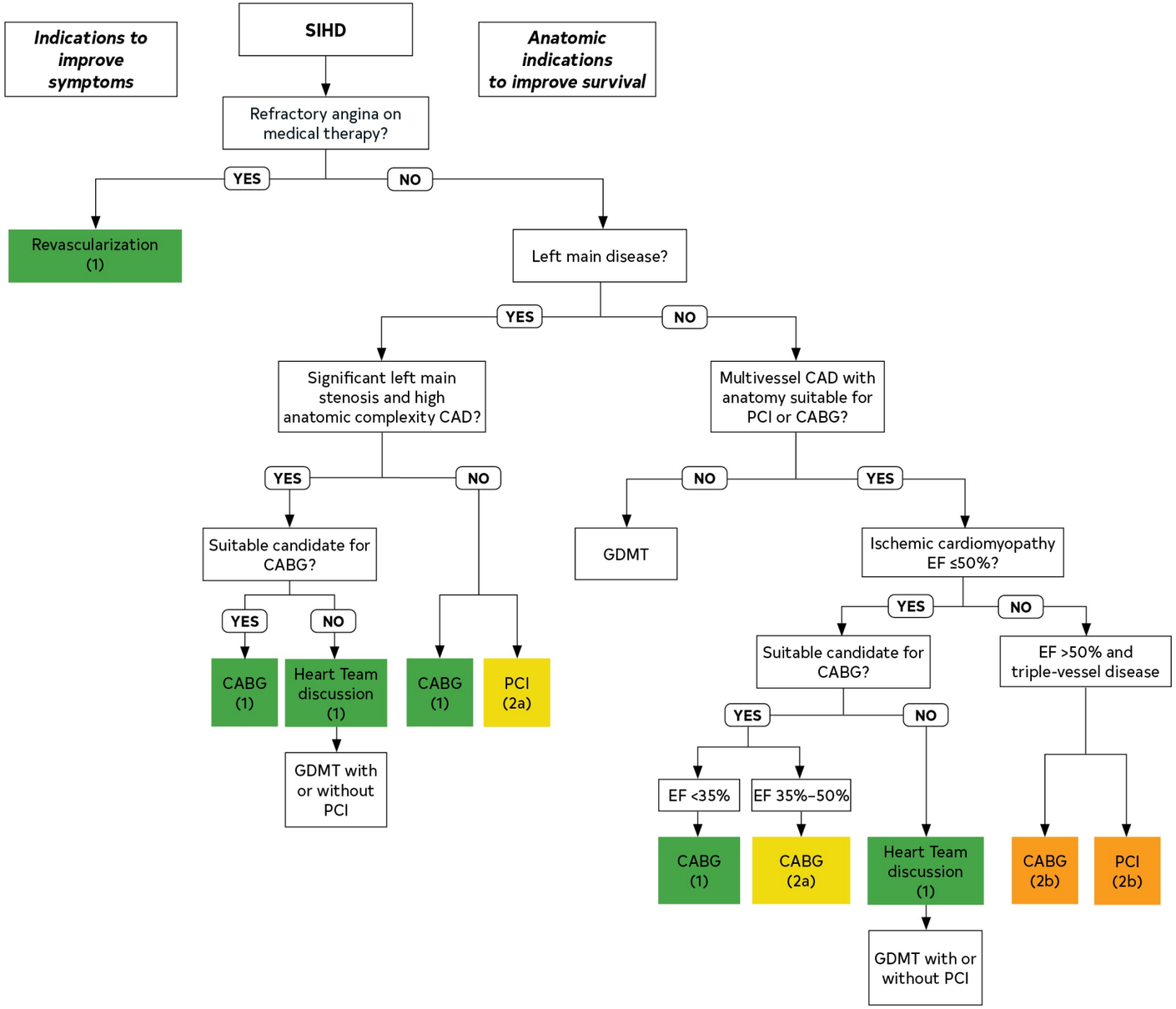
# Revascularization to Improve Survival in SIHD Compared With Medical Therapy (con't.)

| | | |
|---|---|---|
| **3: Harm** | **B-NR** | **9. In patients with SIHD who have ≥1 coronary arteries that are not anatomically or functionally significant (<70% diameter of non–left main coronary artery stenosis, FFR >0.80), coronary revascularization should not be performed with the primary or sole intent to improve survival.** |

# Figure 6. Revascularization in patients with SIHD.

Colors correspond to Table 2.

CABG indicates coronary artery bypass graft; CAD, coronary artery disease; EF, ejection fraction; PCI, percutaneous coronary intervention; SIHD, stable ischemic heart disease; and GDMT, guideline-directed medical therapy.



# Revascularization to reduce cardiovascular events in SIHD compared with medical therapy

| Recommendations for Revascularization to Reduce Cardiovascular Events in SIHD Compared with Medical Therapy<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 11. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **Multivessel CAD** | | |
| **2a** | **B-R** | **1. In patients with SIHD and multivessel CAD appropriate for either CABG or PCI, revascularization is reasonable to lower the risk of cardiovascular events such as spontaneous MI, unplanned urgent revascularizations, or cardiac death.** |

# Revascularization to Improve Symptoms

| Recommendations for Revascularization to Improve Symptoms<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 12. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients with refractory angina despite medical therapy and with significant coronary artery stenoses amenable to revascularization, revascularization is recommended to improve symptoms.** |
| **3: Harm** | **C-LD** | **2. In patients with angina but no anatomic or physiological criteria for revascularization, neither CABG nor PCI should be performed.** |

# Situations in Which PCI or CABG Would Be Preferred

# Patients With Complex Disease

| Recommendations for Patients With Complex Disease<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 13. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **B-R** | **1. In patients who require revascularization for significant left main CAD with high-complexity CAD, it is recommended to choose CABG over PCI to improve survival.** |
| **2a** | **B-R** | **2. In patients who require revascularization for multivessel CAD with complex or diffuse CAD (e.g., SYNTAX score >33), it is reasonable to choose CABG over PCI to confer a survival advantage.** |

# Patients With Diabetes

| Recommendations for Patients With Diabetes<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 14. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients with diabetes and multivessel CAD with the involvement of the LAD, who are appropriate candidates for CABG, CABG (with a LIMA to the LAD) is recommended in preference to PCI to reduce mortality and repeat revascularizations.** |
| **2a** | **B-NR** | **2. In patients with diabetes who have multivessel CAD amenable to PCI and an indication for revascularization and are poor candidates for surgery, PCI can be useful to reduce long-term ischemic outcomes.** |
| **2b** | **B-R** | **3. In patients with diabetes who have left main stenosis and low- or intermediate-complexity CAD in the rest of the coronary anatomy, PCI may be considered an alternative to CABG to reduce major adverse cardiovascular outcomes.** |

# Patients With Previous CABG

| Recommendations for Patients With Previous CABG<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 15. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2a** | **B-NR** | **1. In patients with previous CABG with a patent LIMA to the LAD who need repeat revascularization, if PCI is feasible, it is reasonable to choose PCI over CABG.** |
| **2a** | **C-LD** | **2. In patients with previous CABG and refractory angina on GDMT that is attributable to LAD disease, it is reasonable to choose CABG over PCI when an internal mammary artery (IMA) can be used as a conduit to the LAD.** |
| **2b** | **B-NR** | **3. In patients with previous CABG and complex CAD, it may be reasonable to choose CABG over PCI when an IMA can be used as a conduit to the LAD.** |

# DAPT Adherence

| Recommendation for DAPT Adherence<br>Referenced studies that support the recommendation are summarized in Online Data Supplement 16. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2a** | **B-NR** | **1. In patients with multivessel CAD amenable to treatment with either PCI or CABG who are unable to access, tolerate, or adhere to DAPT for the appropriate duration of treatment, CABG is reasonable in preference to PCI.** |

# Special Populations and Situations

# Revascularization in Pregnant Patients

| Recommendations for Revascularization in Pregnant Patients<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 17. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2a** | **C-LD** | **1. In pregnant patients with STEMI not caused by spontaneous coronary artery dissection (SCAD), it is reasonable to perform primary PCI as the preferred revascularization strategy.** |
| **2a** | **C-LD** | **2. In pregnant patients with NSTE-ACS, an invasive strategy is reasonable if medical therapy is ineffective for the management of life-threatening complications.** |

# Revascularization in Older Patients

| Recommendation for Revascularization in Older Patients<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 18. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **1** | **B-NR** | **1. In older adults, as in all patients, the treatment strategy for CAD should be based on an individual patient's preferences, cognitive function, and life expectancy.** |

# Revascularization in Patients With Chronic Kidney Disease (CKD)

**Recommendations for Revascularization in Patients With CKD**

Referenced studies that support the recommendations are summarized in Online Data Supplement 19.

| COR | LOE | Recommendations |
|---|---|---|
| 1 | C-LD | 1. In patients with CKD undergoing contrast media injection for coronary angiography, measures should be taken to minimize the risk of contrast-induced acute kidney injury (AKI). |
| 1 | C-EO | 2. In patients with STEMI and CKD, coronary angiography and revascularization are recommended, with adequate measures to reduce the risk of AKI. |

# Revascularization in Patients With Chronic Kidney Disease (CKD) (con't.)

| | | |
|---|---|---|
| 2a | B-NR | 3. In high-risk patients with NSTE-ACS and CKD, it is reasonable to perform coronary angiography and revascularization, with adequate measures to reduce the risk of AKI. |
| 2a | C-EO | 4. In low-risk patients with NSTE-ACS and CKD, it is reasonable to weigh the risk of coronary angiography and revascularization against the potential benefit. |
| 3:No benefit | B-R | 5. In asymptomatic patients with stable CAD and CKD, routine angiography and revascularization are not recommended if there is no compelling indication. |

# Table 9. Best Practices in the Catheterization Laboratory for Patients With CKD Undergoing Angiography

| |
|---|
| • Assess the risk of contrast-induced AKI before the procedure |
| • Administer adequate preprocedural hydration |
| • Record the volume of contrast media administered, and minimize contrast use |
| • Pretreat with high-intensity statins |
| • Use radial artery if feasible |
| • Do not administer N-acetyl-L-cysteine to prevent contrast-induced AKI |
| • Do not give prophylactic renal replacement therapy |
| • Delay CABG in stable patients after angiography beyond 24 hours when clinically feasible |

*AKI indicates acute kidney injury; CABG, coronary artery bypass graft; and CKD, chronic kidney disease.*

# Revascularization in Patients Before Noncardiac Surgery

| Recommendation for Revascularization in Patients Before Noncardiac Surgery<br>Referenced studies that support the recommendation are summarized in Online Data Supplement 20. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **3: No benefit** | **B-R** | **1. In patients with non–left main or noncomplex CAD who are undergoing noncardiac surgery, routine coronary revascularization is not recommended solely to reduce perioperative cardiovascular events.** |

# Revascularization in Patients to Reduce Ventricular Arrhythmias

| Recommendations for Revascularization in Patients to Reduce Ventricular Arrhythmias<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 21. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **B-NR** | **1. In patients with ventricular fibrillation, polymorphic ventricular tachycardia (VT), or cardiac arrest, revascularization of significant CAD is recommended to improve survival.** |
| **3: No Benefit** | **C-LD** | **2. In patients with CAD and suspected scar-mediated sustained monomorphic VT, revascularization is not recommended for the sole purpose of preventing recurrent VT.** |

# Revascularization in Patients With SCAD

| Recommendations for Revascularization in Patients With SCAD<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 22. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2b** | **C-LD** | **1. In patients with SCAD who have hemodynamic instability or ongoing ischemia despite conservative therapy, revascularization may be considered if feasible.** |
| **3: Harm** | **C-LD** | **2. Routine revascularization for SCAD should not be performed.** |

# Revascularization in Patients With Cardiac Allografts

| Recommendation for Revascularization in Patients With Cardiac Allografts | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2a** | **C-LD** | **1. In patients with cardiac allograft vasculopathy and severe, proximal, discrete coronary lesions, revascularization with PCI is reasonable (1, 2).** |

# General Procedural Issues for PCI

# Radial and Femoral Approaches for PCI

| Recommendations for Radial and Femoral Approaches for PCI<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 23. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients with ACS undergoing PCI, a radial approach is indicated in preference to a femoral approach to reduce the risk of death, vascular complications, or bleeding.** |
| **1** | **A** | **2. In patients with SIHD undergoing PCI, the radial approach is recommended to reduce access site bleeding and vascular complications.** |

# Choice of Stent Type

| Recommendation for Choice of Stent Type<br>Referenced studies that support the recommendation are summarized in Online Data Supplement 24. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **1** | **A** | **1. In patients undergoing PCI, DES should be used in preference to BMS to prevent restenosis, MI, or acute stent thrombosis.** |

# Use of Intravascular Imaging

| Recommendations for Use of Intravascular Imaging<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 25. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2a** | **B-R** | **1. In patients undergoing coronary stent implantation, IVUS can be useful for procedural guidance, particularly in cases of left main or complex coronary artery stenting, to reduce ischemic events.** |
| **2a** | **B-R** | **2. In patients undergoing coronary stent implantation, OCT is a reasonable alternative to IVUS for procedural guidance, except in ostial left main disease.** |
| **2a** | **C-LD** | **3. In patients with stent failure, IVUS or OCT is reasonable to determine the mechanism of stent failure.** |

# Thrombectomy

| Recommendation for Thrombectomy<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 26. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **3: No Benefit** | **A** | **1. In patients with STEMI, routine aspiration thrombectomy before primary PCI is not useful.** |

# Treatment of Calcified Lesions

| Recommendations for the Treatment of Calcified Lesions<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 27. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2a** | **B-R** | **1. In patients with fibrotic or heavily calcified lesions, plaque modification with rotational atherectomy can be useful to improve procedural success.** |
| **2b** | **B-NR** | **2. In patients with fibrotic or heavily calcified lesions, plaque modification with orbital atherectomy, balloon atherotomy, laser angioplasty, or intracoronary lithotripsy may be considered to improve procedural success.** |

# Treatment of Saphenous Vein Graft (SVG) Disease (Previous CABG)

| Recommendations for Treatment of SVG Disease (Previous CABG)<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 28. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2a** | **B-R** | **1. In select patients with previous CABG undergoing PCI of a SVG, the use of an embolic protection device, when technically feasible, is reasonable to decrease the risk of distal embolization.** |
| **2a** | **B-NR** | **2. In patients with previous CABG, if PCI of a diseased native coronary artery is feasible, then it is reasonable to choose PCI of the native coronary artery over PCI of the severely diseased SVG.** |
| **3: No Benefit** | **C-LD** | **3. In patients with a chronic occlusion of a SVG, percutaneous revascularization of the SVG should not be performed.** |

# Treatment of CTO

| Recommendation for Treatment of CTO<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 29. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2b** | **B-R** | **1. In patients with suitable anatomy who have refractory angina on medical therapy, after treatment of non-CTO lesions, the benefit of PCI of a CTO to improve symptoms is uncertain.** |

# Treatment of Patients With Stent Restenosis

| Recommendations for Treatment of Patients With Stent Restenosis<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 30. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients who develop clinical in-stent restenosis (ISR) for whom repeat PCI is planned, a DES should be used to improve outcomes if anatomic factors are appropriate and the patient is able to comply with DAPT.** |
| **2a** | **C-EO** | **2. In patients with symptomatic recurrent diffuse ISR with an indication for revascularization, CABG can be useful over repeat PCI to reduce recurrent events.** |
| **2b** | **B-NR** | **3. In patients who develop recurrent ISR, brachytherapy may be considered to improve symptoms.** |

# Hemodynamic Support for Complex PCI

| Recommendation for Hemodynamic Support in Complex PCI<br>Referenced studies that support the recommendation are summarized in Online Data Supplement 31. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2b** | **B-R** | **1. In selected high-risk patients, elective insertion of an appropriate hemodynamic support device as an adjunct to PCI may be reasonable to prevent hemodynamic compromise during PCI.** |

# Pharmacotherapy in Patients Undergoing PCI

# Aspirin and Oral P2Y12 Inhibitors in Patients Undergoing PCI

| Recommendations for Aspirin and Oral P2Y12 Inhibitors in Patients Undergoing PCI<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 32. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **B-R** | **1. In patients undergoing PCI, a loading dose of aspirin, followed by daily dosing, is recommended to reduce ischemic events.*** |
| **1** | **B-R** | **2. In patients with ACS undergoing PCI, a loading dose of P2Y12 inhibitor, followed by daily dosing, is recommended to reduce ischemic events.** |
| **1** | **C-LD** | **3. In patients with SIHD undergoing PCI, a loading dose of clopidogrel, followed by daily dosing, is recommended to reduce ischemic events.** |

# Aspirin and Oral P2Y12 Inhibitors in Patients Undergoing PCI (con't.)

| | | |
|---|---|---|
| 1 | C-LD | 4. In patients undergoing PCI within 24 hours after fibrinolytic therapy, a loading dose of 300 mg of clopidogrel, followed by daily dosing, is recommended to reduce ischemic events. |
| 2a | B-R | 5. In patients with ACS undergoing PCI, it is reasonable to use ticagrelor or prasugrel in preference to clopidogrel to reduce ischemic events, including stent thrombosis. |
| 2b | B-R | 6. In patients <75 years of age undergoing PCI within 24 hours after fibrinolytic therapy, ticagrelor may be a reasonable alternative to clopidogrel to reduce ischemic events. |
| 3: Harm | B-R | 7. In patients undergoing PCI who have a history of stroke or transient ischemic attack, prasugrel should not be administered. |

# Table 10. Oral and Parental Antiplatelet Agents for Patients Undergoing PCI

| Drug | Loading Dose | Maintenance Dose |
|---|---|---|
| **Oral antiplatelet agents** | | |
| Aspirin | Loading dose of 162-325 mg orally<br><br>Aspirin may be chewed to achieve faster action | Maintenance dose of 75-100 mg orally daily |
| Clopidogrel | Loading dose of 600 mg orally<br><br>A lower loading dose of 300 mg should be considered in patients after fibrinolytic therapy | Maintenance dose of 75 mg orally daily |
| Prasugrel | Loading dose of 60 mg orally | Maintenance dose of 10 mg orally daily<br><br>In patients with body weight <60 kg, a maintenance dose of 5 mg orally daily is recommended<br><br>In patients ≥75 years of age, a dose of 5 mg orally daily can be used if deemed necessary |

# Table 10. Oral and Parental Antiplatelet Agents for Patients Undergoing PCI (con't.)

| | | |
|---|---|---|
| Ticagrelor | Loading dose of 180 mg orally<br><br>Ticagrelor may be chewed to achieve faster action | Maintenance dose of 90 mg orally twice a day |
| **Intravenous antiplatelet agents** | | |
| Abciximab (GPI)* | Bolus of 0.25 mg/kg | Maintenance of 0.125 µg/kg/min infusion (maximum 10 g/min) for 12 h. |
| Eptifibatide (GPI) | Double bolus of 180 µg/kg (given at a 10-min interval) | Maintenance infusion of 2.0 µg/kg/min for up to 18 h |
| Tirofiban (GPI) | Bolus of 25 µg/kg over 3 min | Maintenance infusion of 0.15 µg/kg/min for up to 18 h |
| Cangrelor | Bolus of 30 µg/kg | Maintenance infusion 4 µg/kg/min for at least 2 h or duration of the procedure, whichever is longer |

*GPI indicates glycoprotein IIb/IIIa inhibitor; and PCI, percutaneous coronary intervention.*

*Abciximab may not be readily available to clinicians in the U.S.

# Intravenous P2Y12 Inhibitors in Patients Undergoing PCI

| Recommendation for Intravenous P2Y12 Inhibitors in Patients Undergoing PCI<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 33. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2b** | **B-R** | **1. In patients undergoing PCI who are P2Y12 inhibitor naïve, intravenous cangrelor may be reasonable to reduce periprocedural ischemic events.** |

# Intravenous Glycoprotein IIb/IIIa Inhibitors in Patients Undergoing PCI

| Recommendations for Glycoprotein IIb/IIIa Inhibitors in Patients Undergoing PCI<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 34. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2a** | **C-LD** | **1. In patients with ACS undergoing PCI with large thrombus burden, no-reflow, or slow flow, intravenous glycoprotein IIb/IIIa inhibitor agents are reasonable to improve procedural success.** |
| **3: No Benefit** | **B-R** | **2. In patients with SIHD undergoing PCI, the routine use of an intravenous glycoprotein IIb/IIIa inhibitor agent is not recommended.** |

# Heparin, Low-Molecular-Weight Heparin, and Bivalirudin in Patients Undergoing PCI

| Recommendations for Heparin, Low-Molecular-Weight Heparin, and Bivalirudin in Patients Undergoing PCI<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 35. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **C-EO** | **1. In patients undergoing PCI, administration of intravenous unfractionated heparin (UFH) is useful to reduce ischemic events.** |
| **1** | **C-LD** | **2. In patients with heparin-induced thrombocytopenia undergoing PCI, bivalirudin or argatroban should be used to replace UFH to avoid thrombotic complications.** |

# Heparin, Low-Molecular-Weight Heparin, and Bivalirudin in Patients Undergoing PCI (con't.)

| | | |
|---|---|---|
| 2b | A | 3. In patients undergoing PCI, bivalirudin may be a reasonable alternative to UFH to reduce bleeding. |
| 2b | B-R | 4. In patients treated with upstream subcutaneous enoxaparin for unstable angina or NSTE-ACS, the use of intravenous enoxaparin may be considered at the time of PCI to reduce ischemic events. |
| 3: Harm | B-R | 5. In patients on therapeutic subcutaneous enoxaparin, in whom the last dose was administered within 12 hours of PCI, UFH should not be used for PCI and may increase bleeding. |

# Table 11. Anticoagulant Dosing During PCI*

| Dosing of Parenteral Anticoagulants During PCI | | |
|---|---|---|
| **Drug** | **Patient Has Received Previous Anticoagulant Therapy** | **Patient Has Not Received Previous Anticoagulant Therapy** |
| UFH | • Additional UFH as needed (e.g., 2000–5000 U) to achieve an ACT of 250-300 s* | 70–100 U/kg initial bolus to achieve target ACT of 250–300 s* |
| Enoxaparin | • For previous treatment with enoxaparin, if the last SC dose was administered 8–12 h earlier or if only 1 SC dose of enoxaparin has been administered, an IV dose of 0.3 mg/kg of enoxaparin should be given<br>• If the last SC dose was administered within the previous 8 h, no additional enoxaparin should be given | • 0.5–0.75 mg/kg IV bolus |

# Table 11. Anticoagulant Dosing During PCI* (con't.)

| | | |
|---|---|---|
| Bivalirudin | • For patients who have received UFH, repeat ACT<br>• If ACT is not in therapeutic range, then give 0.75 mg/kg IV bolus, then 1.75 mg/kg/h IV infusion | • 0.75 mg/kg bolus, 1.75 mg/kg/h IV infusion |
| Argatroban | • 200 µg/kg IV bolus, then 15 µg/kg/min IV infusion | • 350 µg/kg, then 15 µg/kg/min IV infusion |

*Target ACTs for UFH dosing shown for HemoTec (GmbH, Switzerland) or I-Stat (Abbott) device. For Hemochron ACT (Werfen) devices, ACT goals are 50 s higher. In the case of CTO or ACS, consider higher target ACT. If IV glycoprotein IIb/IIIa receptor inhibitor is planned, target ACT 200–250 s.

ACS indicates acute coronary syndrome; ACT, activated clotting time; CTO, chronic total occlusion; IV, intravenous; PCI, percutaneous coronary intervention; SC, subcutaneous; and UFH, unfractionated heparin.

# General Procedural Issues for CABG

# Perioperative Considerations in Patients Undergoing CABG

| Recommendation for Perioperative Considerations in Patients Undergoing CABG<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 36. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **1** | **B-NR** | **1. For patients undergoing CABG, establishment of multidisciplinary, evidence-based perioperative management programs is recommended to optimize analgesia, minimize opioid exposure, prevent complications and to reduce time to extubation, length of stay, and healthcare costs.** |

# Table 12. Perioperative Anesthetic and Monitoring Considerations for CABG

| **Anesthetic considerations** | |
|---|---|
| Perioperative analgesia | Nonopioid medications (e.g., acetaminophen, ketamine, dexmedetomidine) and/or regional techniques (e.g., truncal nerve blocks), particularly as part of a multimodal analgesic approach, have been shown to reduce perioperative opioid use in cardiac surgery. |
| Maintenance anesthesia | Although volatile (versus intravenous) anesthesia may facilitate earlier extubation, recent evidence suggests that the choice of maintenance anesthetic likely does not impact mortality rate after cardiac surgery. |
| Mechanical ventilation | An intraoperative lung-protective ventilation strategy (i.e., tidal volume of 6–8 mL/kg predicted body weight + positive end-expiratory pressure) has been shown to improve pulmonary mechanics and reduce postoperative pulmonary complications. |
| Goal-directed therapy | Goal-directed therapy, which creates protocols for the use of fluids and vasopressors to target specific hemodynamic goals, has yielded inconsistent results and requires additional investigation to determine its use in cardiac surgery. |

# Table 12. Perioperative Anesthetic and Monitoring Considerations for CABG (con't.)

| | |
|---|---|
| **TEE** | |
| CABG + valve procedures | Intraoperative TEE aids in the real-time assessment of heart valve function and pathology in those undergoing combination CABG and valve surgery. |
| Isolated CABG procedures | The use of intraoperative TEE in isolated CABG is less established but has been shown to aid in surgical and anesthetic decision-making as a tool for real-time assessment of hemodynamic status, regional wall motion, ventricular function, valve anatomy, and diastolic function. |
| **Pulmonary artery catheters** | |
| High-risk surgery | Highly selective use of pulmonary artery catheters for high-risk patients (i.e., older, with congestive heart failure, pulmonary hypertension, or previous multiple valve procedures) may be safe and may potentially aid in the surveillance and treatment of hemodynamic instability. |
| Low-risk surgery | The use of pulmonary artery catheters in low-risk or clinically stable patients is discouraged because the practice is associated with increased interventions that incur greater healthcare expense without associated improvement in morbidity or mortality. |

# Table 12. Perioperative Anesthetic and Monitoring Considerations for CABG (con't.)

| CNS monitoring | |
|---|---|
| Cerebral oxygen saturation | Intraoperative monitoring of cerebral oxygen saturation (i.e., near-infrared spectroscopy) to detect cerebral hypoperfusion has been shown to guide anesthetic decision-making and may prevent postoperative neurocognitive dysfunction. |
| Processed electroencephalogram | Routine use of intraoperative monitoring of processed electroencephalogram (i.e., bispectral index) has yielded inconsistent results with respect to the prevention of recall, determination of depth of anesthesia, or improvement in rate of recovery after cardiac surgery. |

CABG indicates coronary artery bypass graft; CNS, central nervous system; and TEE, transesophageal echocardiography.

# Bypass Conduits in Patients Undergoing CABG

| Recommendations for Bypass Conduits in Patients Undergoing CABG<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 37. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **B-R** | **1. In patients undergoing isolated CABG, the use of a radial artery is recommended in preference to a saphenous vein conduit to graft the second most important, significantly stenosed, non–LAD vessel to improve long-term cardiac outcomes.** |
| **1** | **B-NR** | **2. In patients undergoing CABG, an IMA, preferably the left, should be used to bypass the LAD when bypass of the LAD is indicated to improve survival and reduce recurrent ischemic events.** |
| **2a** | **B-NR** | **3. In patients undergoing CABG, bilateral IMA (BIMA) grafting by experienced operators can be beneficial in appropriate patients to improve long-term cardiac outcomes.** |

# Table 13. Best Practices for the Use of Bypass Conduits in CABG

| |
|---|
| • Objectively assess palmar arch completeness and ulnar compensation before harvesting the radial artery. Use the arm with the best ulnar compensation for radial artery harvesting. |
| • Use radial artery grafts to target vessels with subocclusive stenoses. |
| • Avoid the use of the radial artery after transradial catheterization. |
| • Avoid the use of the radial artery in patients with chronic kidney disease and a high likelihood of rapid progression to hemodialysis. |
| • Use oral calcium channel blockers for the first postoperative year after radial artery grafting. |
| • Avoid bilateral percutaneous or surgical radial artery procedures in patients with coronary artery disease to preserve the artery for future use. |
| • Harvest the internal mammary artery using the skeletonization technique to reduce the risk of sternal wound complications. |
| • Use an endoscopic saphenous vein harvest technique in patients at risk of wound complications. |
| • Use a no-touch saphenous vein harvest technique in patients at low risk of wound complications. |
| • Use the skeletonized right gastroepiploic artery to graft right coronary artery target vessels with subocclusive stenosis if the operator is experienced with the use of the artery. |

CABG indicates coronary artery bypass graft.

# CABG in Patients Undergoing Other Cardiac Surgery

| Recommendations for CABG in Patients Undergoing Other Cardiac Surgery<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 38. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **C-LD** | **1. In patients undergoing valve surgery, aortic surgery, or other cardiac operations who have significant CAD, CABG is recommended with a goal of reducing ischemic events.** |
| **2b** | **C-LD** | **2. In patients undergoing valve surgery, aortic surgery, or other cardiac operations who have intermediate CAD, CABG may be reasonable with a goal of reducing ischemic events.** |

# Use of Epiaortic Ultrasound in Patients Undergoing CABG

| Recommendation for Use of Epiaortic Ultrasound in Patients Undergoing CABG<br>Referenced studies that support the recommendation are summarized in Online Data Supplement 39. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2a** | **B-NR** | **1. In patients undergoing CABG, the routine use of epiaortic ultrasound scanning can be useful to evaluate the presence, location, and severity of plaque in the ascending aorta to reduce the incidence of atheroembolic complications.** |

# Use of Cardiopulmonary Bypass in Patients Undergoing CABG

| Recommendations for Use of Cardiopulmonary Bypass in Patients Undergoing CABG<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 40. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2a** | **B-R** | **1. In patients with significant calcification of the aorta, the use of techniques to avoid aortic manipulation (off-pump techniques or beating heart) is reasonable to decrease the incidence of perioperative stroke when performed by experienced surgeons.** |
| **2b** | **B-R** | **2. In patients with significant pulmonary disease, off-pump surgery may be reasonable to reduce perioperative risk when performed by experienced surgeons.** |

# Pharmacotherapy in Patients Undergoing CABG

# Insulin Infusion and Other Measures to Reduce Sternal Wound Infection in Patients Undergoing CABG

| Recommendations for Insulin Infusion and Other Measures to Reduce Sternal Wound Infection in Patients Undergoing CABG<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 41. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **B-R** | **1. In patients undergoing CABG, an intraoperative continuous insulin infusion should be initiated to maintain serum glucose level <180 mg/dL to reduce sternal wound infection.** |

# Insulin Infusion and Other Measures to Reduce Sternal Wound Infection in Patients Undergoing CABG (con't.)

| | | |
|---|---|---|
| 1 | B-R | 2. In patients undergoing CABG, the use of continuous intravenous insulin to achieve and maintain an early postoperative blood glucose concentration of <180 mg/dL while avoiding hypoglycemia is indicated to reduce the incidence of adverse events, including deep sternal wound infection. |
| 1 | B-NR | 3. In patients undergoing CABG, a comprehensive approach to reduce sternal wound infection is recommended. |
| 2b | B-R | 4. In patients undergoing CABG, the usefulness of continuous intravenous insulin designed to achieve a target intraoperative blood glucose concentration <140 mg/dL is uncertain. |

# Table 15. Best Practices to Reduce Sternal Wound Infection in Patients Undergoing CABG

| |
|---|
| • Perform nasal swab testing for *Staphylococcus aureus*.<br>• Apply mupirocin 2% ointment to known nasal carriers of *S aureus*. |
| • Apply preoperative intranasal mupirocin 2% ointment to those patients whose nasal culture or PCR result is unknown. |
| • Redose prophylactic antimicrobials for long procedures (>2 half-lives of the antibiotic) or in cases of excessive blood loss during CABG. |
| • Measure perioperative $HbA_{1c}$. |
| • Treat all distant extrathoracic infections before nonemergency surgical coronary revascularization. |
| • Advise smoking cessation before elective CABG surgery. |
| • Apply topical antibiotics (vancomycin) to the cut edges of the sternum on opening and before closing in cardiac surgical procedures involving a median sternotomy. |
| • Use skeletonized harvest of IMA in BIMA grafting. |
| • Do not continue prophylactic antibiotics beyond 48 hours. |

BIMA indicates bilateral internal mammary artery; CABG, coronary artery bypass graft; HbA1c, glycated hemoglobin A1c; IMA, internal mammary artery; and PCR, polymerase chain reaction.

# Antiplatelet Therapy in Patients Undergoing CABG

| Recommendations for Antiplatelet Therapy in Patients Undergoing CABG<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 42. | | |
|---|---|---|
| COR | LOE | Recommendations |
| 1 | B-R | 1. In patients undergoing CABG who are already taking daily aspirin preoperatively, it is recommended that they continue taking aspirin until the time of surgery to reduce ischemic events. |
| 1 | B-NR | 2. In patients referred for urgent CABG, clopidogrel and ticagrelor should be discontinued for at least 24 hours before surgery to reduce major bleeding complications. |

# Antiplatelet Therapy in Patients Undergoing CABG (con't.)

| | | |
|---|---|---|
| 1 | B-NR | 3. In patients undergoing CABG, discontinuation of short-acting glycoprotein IIb/IIIa inhibitors (eptifibatide and tirofiban) for 4 hours and abciximab for 12 hours before surgery is recommended to reduce the risk of bleeding and transfusion. |
| 2a | B-NR | 4. In patients undergoing elective CABG who receive P2Y12 receptor inhibitors before surgery, it is reasonable to discontinue clopidogrel for 5 days, ticagrelor for 3 days, and prasugrel for 7 days before CABG to reduce risk of major bleeding and blood product transfusion. |
| 3: No benefit | B-R | 5. In patients undergoing elective CABG who are not already taking aspirin, the initiation of aspirin (100–300 mg daily) in the immediate preoperative period (<24 hours before surgery) is not recommended. |

# Beta Blockers and Amiodarone in Patients Undergoing CABG

| Recommendations for Beta Blockers and Amiodarone in Patients Undergoing CABG<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 43. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **2a** | **B-R** | **1. In patients undergoing CABG, who do not have a contraindication to beta blockers, the administration of beta blockers before surgery can be beneficial to reduce the incidence of postoperative atrial fibrillation.** |
| **2a** | **B-R** | **2. In patients undergoing CABG, preoperative amiodarone is reasonable to reduce the incidence of postoperative atrial fibrillation.** |

# Beta Blockers and Amiodarone in Patients Undergoing CABG (con't.)

| | | |
|---|---|---|
| 2b | B-NR | 3. In patients undergoing CABG, who do not have a contraindication to beta blockers, preoperative use of beta blockers may be effective in reducing in-hospital and 30-day mortality rates. |
| 2b | B-NR | 4. In patients undergoing CABG, the role of preoperative beta blockers for the prevention of acute postoperative myocardial ischemia, stroke, AKI, or ventricular arrhythmia is uncertain. |

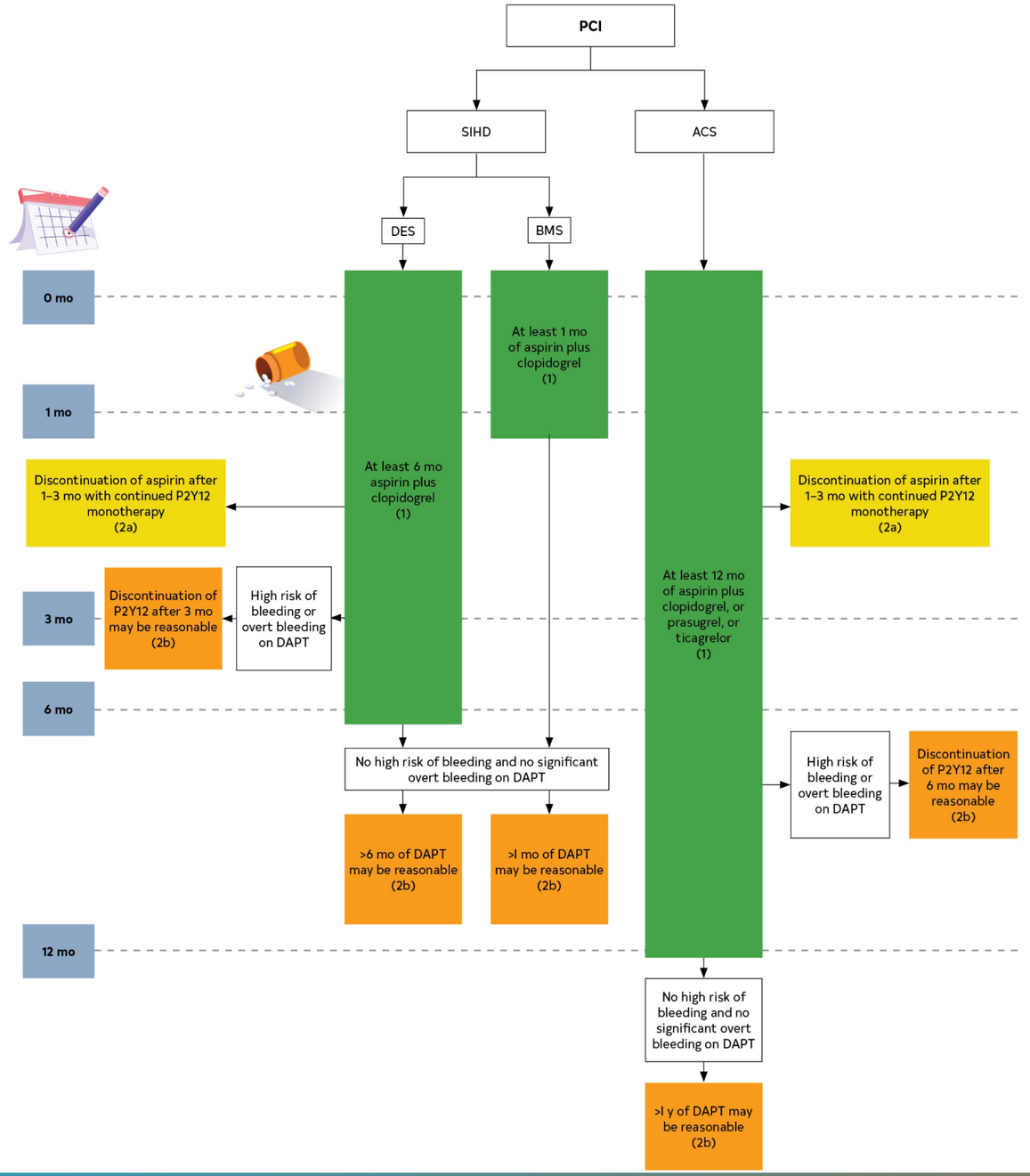
# Pharmacotherapy in Patients After Revascularization

# Dual Antiplatelet Therapy in Patients After PCI

| Recommendation for Dual Antiplatelet Therapy in Patients After PCI<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 44. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2a** | **A** | **1. In selected patients undergoing PCI, shorter-duration DAPT (1–3 months) is reasonable, with subsequent transition to P2Y12 inhibitor monotherapy to reduce the risk of bleeding events.** |

# Figure 7. Use of DAPT for patients after PCI.

Colors correspond to Table 2.




ACS indicates acute coronary syndrome; BMS, bare metal stent; DAPT, dual antiplatelet therapy; DES, drug-eluting stent; P2Y12, platelet adenosine diphosphate P2Y12 receptor; PCI, percutaneous coronary intervention; and SIHD, stable ischemic heart disease.

# Antiplatelet Therapy in Patients After CABG

| Recommendations for Antiplatelet Therapy in Patients After CABG<br>Referenced studies that support the recommendations are summarized in Online Data Supplement 45. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients undergoing CABG, aspirin (100–325 mg daily) should be initiated within 6 hours postoperatively and then continued indefinitely to reduce the occurrence of SVG closure and adverse cardiovascular events.** |
| **2b** | **B-R** | **2. In selected patients undergoing CABG, DAPT with aspirin and ticagrelor or clopidogrel for 1 year may be reasonable to improve vein graft patency compared with aspirin alone.** |

# Beta Blockers in Patients After Revascularization

| Recommendations for Beta Blockers in Patients After Revascularization<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 46. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **3: No benefit** | **C-LD** | **1. In patients with SIHD and normal left ventricular function, the routine use of chronic oral beta blockers is not beneficial to reduce cardiovascular events after complete revascularization.** |

# Beta Blockers for the Prevention of Atrial Fibrillation After CABG

| Recommendation for Beta Blockers for the Prevention of Atrial Fibrillation After CABG<br><br>Referenced studies that support the recommendation are summarized in Online Data Supplement 47. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **1** | **B-R** | **1. In patients after CABG, beta blockers are recommended and should be started as soon as possible to reduce the incidence or clinical sequelae of postoperative atrial fibrillation.** |

# Antiplatelet Therapy in Patients With Atrial Fibrillation on Anticoagulation After PCI

| Antiplatelet Therapy in Patients With Atrial Fibrillation on Anticoagulation After PCI<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 48. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **B-R** | **1. In patients with atrial fibrillation who are undergoing PCI and are taking oral anticoagulant therapy, it is recommended to discontinue aspirin treatment after 1 to 4 weeks while maintaining P2Y12 inhibitors in addition to a non–vitamin K oral anticoagulant (rivaroxaban, dabigatran, apixaban, or edoxaban) or warfarin to reduce the risk of bleeding.** |
| **2a** | **B-R** | **2. In patients with atrial fibrillation who are undergoing PCI, are taking oral anticoagulant therapy, and are treated with DAPT or a P2Y12 inhibitor monotherapy, it is reasonable to choose a non–vitamin K oral anticoagulant over warfarin to reduce the risk of bleeding.** |

# Recommendations for Addressing Psychosocial Factors and Lifestyle Changes After Revascularization

# Cardiac Rehabilitation and Education

| Recommendations for Cardiac Rehabilitation and Education<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 49. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients who have undergone revascularization, a comprehensive cardiac rehabilitation program (home based or center based) should be prescribed either before hospital discharge or during the first outpatient visit to reduce deaths and hospital readmissions and improve quality of life.** |
| **1** | **C-LD** | **2. Patients who have undergone revascularization should be educated about CVD risk factors and their modification to reduce cardiovascular events.** |

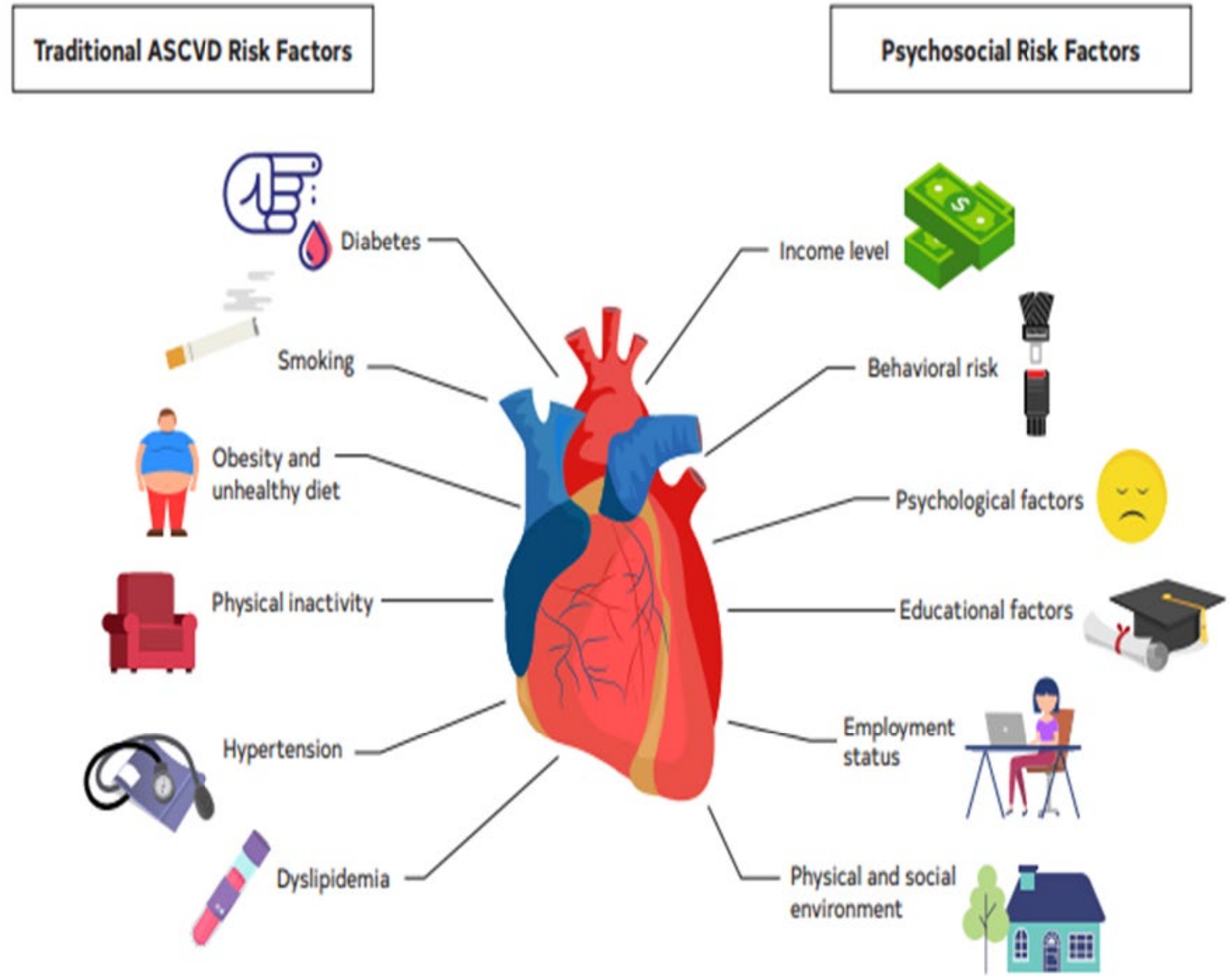
# Smoking Cessation in Patients After Revascularization

| Recommendations for Smoking Cessation in Patients After Revascularization<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 50. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **A** | **1. In patients who use tobacco and have undergone coronary revascularization, a combination of behavioral interventions plus pharmacotherapy is recommended to maximize cessation and reduce adverse cardiac events.** |
| **1** | **A** | **2. In patients who use tobacco and have undergone coronary revascularization, smoking cessation interventions are recommended during hospitalization and should include supportive follow-up for at least 1 month after discharge to facilitate tobacco cessation and reduce morbidity and mortality.** |

# Psychological Interventions in Patients After Revascularization

| Recommendations for Psychological Interventions in Patients After Revascularization<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 51. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **B-R** | **1. In patients who have undergone coronary revascularization who have symptoms of depression, anxiety, or stress, treatment with cognitive behavioral therapy, psychological counseling, and/or pharmacological interventions is beneficial to improve quality of life and cardiac outcomes.** |
| **2b** | **C-LD** | **2. In patients who have undergone coronary revascularization, it may be reasonable to screen for depression and refer or treat when it is indicated to improve quality of life and recovery.** |

# Figure 8. Traditional and nontraditional risk factors for CVD.




ASCVD indicates atherosclerotic cardiovascular disease; and CVD, cardiovascular disease.

# Revascularization Outcomes

# Assessment of Outcomes in Patients After Revascularization

| Recommendations for Assessment of Outcomes in Patients After Revascularization<br><br>Referenced studies that support the recommendations are summarized in Online Data Supplement 52. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendations** |
| **1** | **B-NR** | **1. With the goal of improving patient outcomes, it is recommended that cardiac surgery and PCI programs participate in state, regional, or national clinical data registries and receive periodic reports of their risk-adjusted outcomes as a quality assessment and improvement strategy.** |
| **2a** | **C-LD** | **2. With the goal of improving patient outcomes, it is reasonable for cardiac surgery and PCI programs to have a quality improvement program that routinely 1) reviews institutional quality programs and outcomes, 2) reviews individual operator outcomes, 3) provides peer review of difficult or complicated cases, and 4) performs random case reviews.** |
| **2b** | **C-EO** | **3. Smaller volume cardiac surgery and PCI programs may consider affiliation with a high-volume centers to improve patient care.** |

# Abbreviations used in this Guideline

| Abbreviation | Meaning/Phrase |
|---|---|
| ACS | acute coronary syndrome |
| AKI | acute kidney injury |
| AMI | acute myocardial infarction |
| AVR | aortic valve replacement |
| BIMA | bilateral internal mammary artery |
| BMS | bare-metal stent |
| CABG | coronary artery bypass graft |
| CAD | coronary artery disease |
| CKD | chronic kidney disease |
| COR | Class of Recommendation |
| CTO | chronic total occlusion |
| CVD | cardiovascular disease |
| DAPT | dual antiplatelet therapy |
| DES | drug-eluting stent |
| ECG | electrocardiogram |
| FFR | fractional flow reserve |
| GDMT | guideline-directed medical therapy |
| iFR | instantaneous wave-free ratio |
| IMA | internal mammary artery |
| ISR | in-stent restenosis |

# Abbreviations used in this Guideline

| | |
|---|---|
| IVUS | intravascular ultrasound |
| LAD | left anterior descending |
| LIMA | left internal mammary artery |
| LOE | Level of Evidence |
| MACE | major adverse cardiovascular events |
| MI | myocardial infarction |
| NSTE-ACS | non–ST-segment–elevation acute coronary syndrome |
| NSTEMI | non–ST-segment–elevation myocardial infarction |
| OCT | optical coherence tomography |
| PCI | percutaneous coronary intervention |
| RCT | randomized controlled trial |
| SCAD | spontaneous coronary artery dissection |
| SIHD | stable ischemic heart disease |
| STEMI | ST-segment–elevation myocardial infarction |
| SVG | saphenous vein graft |
| SYNTAX | Synergy Between PCI With TAXUS and Cardiac Surgery |
| TAVR | transcatheter aortic valve replacement |
| UFH | unfractionated heparin |
| VT | ventricular tachycardia |