the presence of large areas of myocardial ischemia documented by noninvasive imaging. The two types of revascularization procedures are coronary bypass grafting (CABG) and percutaneous coronary intervention (PCI).

Percutaneous transluminal coronary angioplasty was the initial mode of catheter-based revascularization introduced in the late 1970s (see Video, Angioplasty, http://www.heartsite.com/html/ptca.html). In this technique, a guidewire is placed through a stenotic segment of artery, after which a balloon-tipped catheter is threaded over the wire to the area of stenosis and then inflated. Angioplasty of this form enlarges the vessel lumen in an irregular geometry through disruption of the plaque and injury to the vessel intima. Plain old balloon angioplasty (POBA), as the procedure later became to be known, was effective at improving myocardial perfusion and reducing exercise-related angina. However, because of plaque disruption, there was a 2% to 5% risk of abrupt vessel closure frequently leading to MI. In addition, there was a high incidence of injury-mediated restenosis (up to 50%) during the first 3 to 6 months after the procedure. The process of restenosis involved intimal hyperplasia and remodeling, yielding a recurrent stenosis sometimes more severe in nature than the original lesion.

The innovation of coronary stents pioneered through the 1980s and clinically available in the early 1990s represented a significant advance in PCI (see Video, Intracoronary Stenting, http://www.heartsite.com/html/stent.html). Coronary stents are expandable metallic mesh tubes that are mounted on an angioplasty balloon, allowing delivery to an area of stenosis, where balloon inflation expands the stent into the vessel wall. The stent becomes permanently embedded in the vessel wall and scaffolds the artery to keep it open. This procedure not only reduces the risk of abrupt vessel occlusion to 1% or less, but it is also associated with a significant reduction in restenosis risk (20% to 25%, compared with 50% for POBA). The benefit of stenting for a patient is clear in terms of less risk of procedure-related acute MI and less need for repeat procedures. Vessels smaller than 2 mm in diameter are not good targets for stenting, because the smallest-diameter stent is 2 mm. Stents do have a risk of thrombosis, necessitating lifelong aspirin therapy and the use of clopidogrel for 4 weeks to 1 year after the procedure (there may be some advantage to longer-duration clopidogrel for 1 year).

Despite the reduction achieved with coronary stents, there was still a significant risk of restenosis, leading investigators to search for a means to lower that risk. Drug-eluting stents (DES) were found to significantly reduce the risk of restenosis compared to bare metal stents. The first DES, released for use in 2003, was coated with either sirolimus or paclitaxel, both of which inhibited the hyperplastic response in the vessel wall triggered by PCI. The current generations of DES are coated with either zotarolimus or everolimus, both very effective at reducing restenosis. The predicted restenosis rate for current-generation DES is in the range of 5% to 10%. Vessel diameter affects restenosis risk, with larger-diameter vessels demonstrating less restenosis. The benefit of inhibiting tissue overgrowth within the stent is also associated with delayed endothelialization of the stent, which increases the risk of stent thrombosis for a longer time than with bare metal stents. Therefore, dual antiplatelet therapy with aspirin and clopidogrel should be maintained for at least 1 year. Aspirin should never be discontinued after 1 year, to minimize the risk of late stent thrombosis. Decision making regarding the use of DES needs to take into account the patient's ability to tolerate long-term dual antiplatelet therapy, the potential for noncompliance with medications, and any need for major surgery in the near future after stent placement. The benefits of DES also confer the need for additional planning and caution.

A host of other devices to treat stenotic coronary arteries have come and gone over time. In this era, rotational atherectomy plays a role in treating calcified lesions in about 5% of patients. Catheter-based aspiration of thrombus has gained a role in patients with STEMI. Intravascular ultrasound is an important imaging adjunct than can be helpful in interrogating lesions or defining the end result of stent placement.

CABG emerged in the 1970s as an effective means of coronary revascularization for the control of angina. Bypass grafts take the form of saphenous vein from the leg, free radial artery segments, or intact left or right internal mammary artery grafts. The vein or radial artery grafts are placed on the ascending aorta and then anastomosed to the coronary vessels distal to the site of obstruction. In contrast, left or right internal mammary arteries are left intact at their origins and anastomosed distal to the obstruction. The left internal mammary artery is typically placed onto the left anterior descending coronary artery. This is the most important vessel to graft because of its size and distribution, and the left internal mammary artery is ideal given an expected patency rate of 90% at 10 years. Saphenous vein grafts degenerate over time, leading to episodes of symptomatic abrupt occlusion and a 50% patency rate at 10 years. Free radial artery grafts perform better than vein grafts but less well than intact mammary artery grafts. CABG is a major cardiac surgical procedure, but in skilled hands the mortality rate is expected to be 1% to 2%, with a similar risk of stroke. Periprocedural MI rates are in the range of 5% to 10%. There has been controversy over whether the use of the heart-lung machine to support CABG causes more problems for patients than "beating heart" surgery does. Recent studies suggest there is no long term difference in outcomes, such as death, MI, or stroke, for patients undergoing CABG, either on- or off-pump.

Most CABG procedures are performed for symptom control and are not likely to enhance longevity. The categories of patients likely to have life prolonged by CABG include those with a left main coronary artery more than 50% narrowed, those with severe three-vessel obstructive disease associated with a decrease in ejection fraction (EF, 35% to 50%), and those with two- or three-artery disease whose proximal left anterior descending artery is severely stenosed.

Clinical trials comparing CABG and PCI have consistently shown that patients undergoing CABG require fewer repeat procedures during the first 2 years after surgery. In the first 2 years, it is more likely that patients with PCI will experience symptomatic restenosis than that patients with CABG will have graft failure. Over time, this advantage is lost as vein grafts begin to fail 5 to 10 years after surgery. However, there is evidence that a survival advantage exists for diabetic patients with multivessel CAD who undergo CABG as opposed to PCI. A recent study also demonstrated long-term survival benefit for CABG over PCI in the face of multivessel CAD. Some of the survival advantage in