



hypertension, diabetes, hypercholesterolemia, and obesity. Aggressive lowering of low-density lipoprotein levels after CABG and the administration of a daily aspirin have been shown to reduce the incidence of venous graft occlusion.

Most cases of recurrent angina can be managed successfully with medication (see [Chapter 9](#)). In many cases, percutaneous revascularization of a native vessel or graft can provide symptomatic relief and is the initial procedure of choice in this setting. In patients with refractory symptoms not amenable to percutaneous revascularization, repeat CABG is an option; however, in this setting, repeat CABG is associated with increased perioperative mortality and less satisfactory long-term control of angina.

Minimally Invasive Cardiac Surgery

Minimally invasive approaches for cardiac surgery can be broadly grouped into two categories: those that avoid the performance of a sternotomy and those that avoid the use of CPB. During the last 15 years, progressive experience incorporating these approaches has led to the application of minimally invasive techniques to selected patients undergoing cardiac surgery. However, many of the approaches have significant limitations, and the field continues to evolve.

In highly selected patients, minimally invasive direct coronary artery bypass (MIDCAB) can be performed through a limited thoracotomy, sparing the patient the perioperative morbidity associated with a median sternotomy. This technique also avoids the use of CPB. The most common approach is through a small left anterior thoracotomy incision. This allows for harvesting of the left internal mammary artery under direct visualization. This technique is most suitable for patients with proximal disease in the distribution of the left anterior descending coronary artery, although other coronary arteries can be bypassed with the use of different thoracotomy approaches. The major limitation of this approach has been the lower patency rates in the left internal mammary grafts placed using this technique and a higher incidence of recurrent ischemia compared with conventional CABG. The MIDCAB procedure therefore is applicable only to highly selected patients with disease in the distribution of the left anterior descending coronary artery and significant comorbidities that preclude the performance of a median sternotomy and use of CPB.

The initial experience with the MIDCAB approach and the subsequent demonstration of its limitations prompted the development of port-access cardiac surgery. This technique incorporates the MIDCAB approach of a limited lateral thoracotomy, thereby avoiding a median sternotomy, but uses CPB to facilitate performance of intracardiac procedures and potential access to other coronary artery distributions beyond the left anterior descending coronary artery for CABG. The port-access approach uses an endoaortic balloon inserted through cannulas placed in the femoral vessels for CPB. A few centers have successfully used the port-access platform for performance of selected cardiac surgical procedures, particularly mitral valve repair or replacement. The widespread adoption of this platform has been limited by persistent difficulties with access to all areas of the heart for coronary revascularization and the potentially catastrophic complication of aortic dissection in a small number of patients.

The limitations encountered with both the MIDCAB and port-access platforms have spurred interest in coronary bypass surgery performed through a median sternotomy but without CPB (e.g., off-pump coronary artery bypass [OPCAB]), allowing for surgery on the beating heart. The advantages of OPCAB over other platforms for minimally invasive coronary surgery are that complete revascularization can be performed and both internal mammary arteries can be harvested. Compared with conventional CABG, OPCAB is associated with decreased blood loss, decreased need for transfusion, decreased myocardial enzyme release up to 24 hours after surgery, decreased renal dysfunction, and, typically, decreased number of grafts placed per patient. OPCAB is not associated with a decreased length of hospital stay, a decreased mortality rate, or improved long-term neurologic function compared with conventional CABG. Although the OPCAB platform has become the most widely adopted approach for minimally invasive cardiac surgery, major questions remain regarding the intermediate and long-term patencies of the bypass grafts placed with this technique and whether the decreased number of grafts placed per patient compromises the long-term cardiac outcomes, compared with conventional CABG. Large-scale prospective clinical trials need to be conducted to answer these questions definitively.

Advances in minimally invasive cardiac surgery have led to the development of robotically assisted cardiac surgery. In this approach, the surgeon sits behind a computer console and uses telemanipulation to guide robotic arms that are placed through ports in the chest wall. On- or off-pump surgeries can be performed, and CPB is achieved through the peripheral cannulation. Although a variety of cardiac surgeries are possible in selected patients, the most commonly performed robotically assisted cardiac procedure is repair or replacement of the mitral valve. CABG can be performed on a beating or arrested heart. The internal mammary artery is typically taken down with the use of the robot, and the distal anastomosis is performed freehand through a mini-thoracotomy or mini-sternotomy incision. Alternatively, totally endoscopic robotic coronary bypass (TECAB) can be performed with good results. Similar procedures using this approach include ablation of atrial fibrillation, resection of intracardiac tumors, closure of atrial septal defects, and implantation or revision of the left ventricular lead of a device.

Other benefits of minimally invasive techniques include a smaller incision, less pain, and shorter length of hospital stay. Advocates of robotically assisted cardiac surgery highlight the improved visualization, panoramic 360-degree views, wrist-like articulation of instruments, improved dexterity, and elimination of hand tremor. These procedures are continually evolving, but their widespread adoption is limited to specialized centers due to significant costs for purchase and maintenance. As the experience with the technology improves, use of robotic approaches is likely to increase and to play a substantial role in the field of minimally invasive cardiac surgery.

Valvular Surgery

Surgical repair or replacement of a diseased valve is dependent on multiple factors, including the type and severity of the valve lesion, the presence of symptoms, and the functional status of the left and, in some cases, the right ventricle (see [Chapter 8](#)). In