INTRODUCTION

Fueled by the success of laparoscopic and thoracoscopic techniques, recent developments in minimally invasive surgery are now being applied to cardiac surgery. The obvious advantages to the patient include a smaller incision, less pain, an improved cosmetic result, and a potentially shorter recovery time. However, owing to the high degree of accuracy and precision required for cardiac surgery and the need for cardiopulmonary bypass (CPB) and myocardial protection for most cardiac surgical procedures, methods of minimally invasive cardiac surgery were slow to develop. Newly proposed techniques for minimally invasive cardiac surgery had to meet the dual challenges of being less invasive while achieving outcomes equivalent to those of established techniques without compromising safety or efficacy. These goals could not be accomplished on a widespread basis with beating heart techniques, nor could these goals be achieved until less invasive methods of extracorporeal perfusion and cardioplectic arrest were developed.

The initial approach to minimally invasive bypass surgery involved working on the beating heart through a limited anterior small thoracotomy (LAST) approach, also known as “keyhole” surgery or minimally invasive direct coronary artery bypass (MIDCAB). Introduced by Calafiore (1) in Europe, this innovative technique quickly spread to the United States, and was clinically implemented by Subramanian and Mack et al. (2–4). Early results have been encouraging in select patients, but the technique appears to be
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applicable primarily to patients with single-vessel coronary disease, a group that accounts for <5% of the overall cardiac surgical population. Obviously, beating heart procedures are not applicable to valvular operations and other complex open-heart repairs. Furthermore, a disadvantage of the beating heart technique has been the need to perform the coronary anastomosis on a moving heart, which introduces the potential for decreased anastomotic precision. It has been speculated, therefore, that this disadvantage will result in graft patency rates that are lower than those achievable with standard procedures using cardioplegic arrest, especially if the beating heart technique is applied to a wider range of patients. The advantages of less invasive cardiac surgery, however, were readily apparent in the patients treated with the beating heart techniques and included reductions in postoperative pain, hospital stay, and recovery time. Thus, minimally invasive cardiac surgery was not only shown to be feasible but was found to offer significant advantages to the patients and to have immense popular appeal.

The next important milestone in minimally invasive cardiac surgery was the development of an endovascular approach first proposed and described by Stevens and coworkers (5) and developed in conjunction with industry. This approach involved the development of a new endovascular system for CPB and cardioplegia delivery (Port-Access, Heartport, Redwood City, CA), which served as a platform allowing wider applicability of minimally invasive cardiac surgery (5). This system relies on the use of peripheral CPB and an endoaortic balloon occlusion catheter, and is designed to achieve standard myocardial protection without the need for a median sternotomy. This approach gives the surgeon the potential to apply fully all the standard techniques of cardiac surgery while minimizing access trauma by the use of small thoracotomy “ports.” The Port-Access technique involves the placement of a group of catheters via the femoral artery, femoral vein, and jugular vein. A small thoracotomy “port” incision is then made over the operative target to accomplish the bypass or valvular operation. With this newly developed system, the heart can be stopped, decompressed, and protected, allowing the surgeon to utilize standard anastomotic techniques on multiple coronary targets with reproducible anastomotic precision. Furthermore, the Port-Access approach can be applied to valvular surgery.

The endovascular bypass and balloon endoclamp system was tested extensively at the Stanford University and New York University (NYU) research laboratories (6–8). The initial reports demonstrated the safety and efficacy of myocardial protection using endovascular CPB and cardioplegic arrest. Other studies from the same groups established the feasibility of minimally invasive multivessel bypass grafting and mitral valve surgery with the Port-Access system, providing a sound scientific basis for expanded clinical use of the system.

Port-Access coronary artery bypass grafting (CABG) using the endovascular perfusion and cardioplegic arrest system described previously, was introduced in 1996. An FDA phase I trial was performed at Stanford University, with subsequent controlled clinical trials introduced at NYU and elsewhere. The technique was rapidly adopted in more than 100 centers throughout the country, probably because it immediately expanded the potential application of minimally invasive cardiac surgery, while allowing the surgeon to use standard, reliable techniques of bypass grafting.