OVERVIEW OF CARDIAC SURGERY

Since heart surgery was pioneered in the mid-1950s, remarkable advances have occurred in the surgical treatment of cardiovascular disease. Coronary artery bypass graft (CABG) procedures are the most effective treatment for coronary artery disease. This treatment utilizes an artery or vein to bypass the narrowing in a coronary artery and restore blood flow downstream of the narrowing. For valvular heart disease (VHD), the treatment involves either repairing the diseased heart valve, most commonly with the implantation of a prosthetic annuloplasty ring, or replacing it with a prosthetic mechanical or tissue valve.

All the surgical procedures in conventional heart surgery require a highly invasive technique, a sternotomy, that involves opening the patient’s chest to gain access to the heart. When performing a sternotomy, the surgeon makes a 12- to 18-inch incision in the patient’s chest, cuts the sternum in half with a bone saw and spreads open the rib cage with a steel retractor. This type of surgery, while efficacious, is traumatic and painful; typically, it is expensive and demands a lengthy period of convalescence.

Less invasive alternatives to conventional heart surgery emerged in the early 1980s. A minimally invasive approach has the potential to significantly reduce cardiac complications, pain and suffering, convalescence and cost, while maintaining the high efficacy of conventional open-chest surgery.

One of these approaches, percutaneous transluminal coronary angioplasty (PTCA) or balloon angioplasty, was developed as an alternative to coronary artery bypass graft (CABG) surgery. While less invasive than conventional CABG, a major drawback of PTCA is the high frequency of restenosis, which occurs at rates ranging from 25 percent to 50 percent. Ultimately, the majority of angioplasty patients undergo another PTCA procedure or CABG surgery.

Another less-invasive alternative to conventional open-chest CABG surgery was developed by a small number of cardiac surgeons. For this procedure, surgeons have been using off-the-shelf tools to perform minimally invasive CABG surgery on the beating heart. However, because this technique subjects the patient to the risk of several types of cardiac stress, beating heart surgery is practical in only a small number of cases that do not require the heart to be opened, turned, or manipulated. Furthermore, the patient must be able to tolerate the stress of undergoing heart surgery without the support of cardiopulmonary bypass and the benefits resulting from stopping the heart.

Many believe that to achieve the high efficacy, patient safety and broad scope of conventional open-chest cardiac surgery, the patient must be placed on cardiopulmonary bypass,
and the heart stopped. Until recently, the only way to place the patient on cardiopulmonary bypass and stop the heart has been to cut open the patient's chest.

A new approach to cardiac surgery permits surgeons to perform the full range of minimally invasive cardiac surgeries, while the patient remains on cardiopulmonary bypass, and the heart stopped. Additionally, this procedure avoids the necessity of a sternotomy and its associated trauma. Instead, this technique relies on technology that incorporates proprietary systems for performing types of minimally invasive heart surgery. The core platform is an endovascular cardiopulmonary bypass system (Endoclamp™, Heartport, Inc.) which allows surgeons to place the patient on cardiopulmonary bypass, stop, and protect the patient's heart without the need for a sternotomy.

Using this device and procedure-specific application systems, the surgeon is able to perform cardiac surgery by accessing the heart through a series of small incisions or "ports" placed between the patient's ribs. The first application systems comprise reusable, disposable, and implantable devices and visualization systems for port-access CABG and for port-access mitral valve replacement or repair surgeries. Application systems for performing additional cardiac surgery procedures, including port-access aortic valve replacement, are also under development.

**PORT-ACCESS CORONARY ARTERY BYPASS GRAFTING**

Minimally invasive port-access cardiac surgery offers a safe, feasible, and less traumatic alternative to the traditional (CABG) surgery, according to Dr Herman Reichenspurner, staff surgeon, Dresden Cardiovascular Center, Dresden, Germany.

"We've had encouraging clinical success with port-access surgery," stated Dr Reichenspurner. "Our findings indicate

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**FIGURES 1 AND 2** illustrate location of cannulas and catheters in minimally-invasive cardiac surgery.
that in addition to significantly reducing the pain and scarring of heart surgery, the port-access approach also can reduce the risk of post-operative complications, dramatically speed recovery, and improve quality of life for patients."

To date, Dr Reichenspurner noted, 48 patients have undergone port-access minimally invasive cardiac surgery (MICS). Of these, 42 were CABG and 16 were mitral valve surgery (4 repair, 12 replacement).

Patients with isolated left anterior descending coronary artery (LAD) lesions were evaluated for port-access CABG, Dr Richenspurner continued. At surgery, a small (6-8 cm) incision was cut parasternally on top of the fourth rib. The cartilaginous portion of the fourth rib was removed. The left internal mammary artery (LIMA) was dissected and taken down through a mini-thoracotomy alone or by using an additional thoracoscopic approach through three small lateral chest ports. The mini-anterior thoracotomy was carried out through the bed of the fourth costal cartilage to facilitate take down of the LIMA in its distal portions, with thorascopic dissection in the proximal portion. Endovascular cardiopulmonary bypass was instituted through femoral cannulation. An endoarterial balloon catheter for aortic occlusion, aortic root venting, aortic root pressure monitoring and delivery of cold antegrade crystalloid cardioplegia was introduced into the ascending aorta through the arterial cannula under fluoroscopy and transesophageal echocardiographic monitoring. Pulmonary artery venting was achieved with a special catheter passed percutaneously through the internal jugular vein and forwarded into the main pulmonary artery. After institution of cardiopulmonary bypass and cardioplegic arrest, the LIMA was anastomosed to the LAD under direct vision. Suturing was done through 10 mm ports.

Overall, Dr Richenspurner said, the median time for the operation is 4.5 hours (approximately one-half of the standard time). All patients were weaned from cardiopulmonary bypass in sinus rhythm without inotropic support. Stay in the intensive care unit is approximately one day, and median time in hospital is two to six days, compared to the six to 10 days required with standard CABG surgery. Intraoperative angiographs demonstrated full left mammary artery patency, with no stenosis, in all 42 persons who underwent the port-access CABG procedure.

Following surgery, Dr Reichenspurner explained, two patients had delayed wound healing in the femoral aorta; two persons had pleural effusions, three individuals suffered from postoperative hemorrhage, and one patient developed a post-cardiotomy syndrome. Of the complications observed, all but three were minor and were relative to problems of bleeding or wound healing, which would be anticipated with standard CABG surgery. Because the surgeons have gained substantial experience, port-access surgery is now considered a routine procedure at Dresden Hospital.

Due to rapid mobilization, Dr Reichenspurner concluded, the time to discharge was justifiable at an earlier stage compared with conventional CABG patients. At two weeks, six weeks, and, in the earliest cases, six months follow-up, all patients presented with rapid recovery without any morbidity. Control angiograms, three months after surgery, show ideal post-operative findings (no leakage, flow well).

PORT-ACCESS MITRAL VALVE REPAIR OR REPLACEMENT

Port-access mitral valve replacement also has been demonstrated to be safe and feasible, declared Dr Mario F Pompii, assistant clinical professor of surgery at Stanford University School of Medicine, and Palo Alto VA Healthcare System, Palo Alto, California. In all of the cases employing this new technique, patients experienced the benefits of cardioplegic arrest and the mitral valve replacement without the trauma of a median sternotomy or thoracotomy.

In this initial clinical experience, Dr Pompii said four patients underwent port-access mitral valve replacement through a small incision (8.0 to 15 cm) over the fourth intercostal space, with removal of a short segment of rib in three patients. Single lung ventilation was used. Cardiopulmonary bypass was established through the femoral artery and vein. Through the femoral artery, the Endo-Clamp™ endoscopic aortic occlusion balloon catheter, also used for cardioplegia delivery and root venting, was placed. After cardioplegic arrest, a standard left atriotomy was performed. The valve was partially or completely excised, and a St Jude Medical prosthesis seat and secured. Excellent exposure of the mitral valve was gained by direct vision and with the aid of a thorascopoe. The left atriotomy was closed and deairing performed.
Overall, Dr. Pompii noted, intraoperative transesophageal echocardiography demonstrated that the prosthesis was well seated with unhampered leaflet motion and preserved ventricular function in all patients. Three individuals were weaned from cardiopulmonary bypass without inotropic support and one person required dopamine.

**PRESENT STATUS OF PORT-ACCESS CARDIAC SURGERY**

To date, a total of 150 CABG and mitral valve procedures using the Heartport system have been carried out at centers worldwide, stated Dr. Bruce A. Reitz, professor and chair, cardiothoracic surgery, Stanford University School of Medicine, Stanford, California. In the United States, the procedure was initially developed at Stanford and is performed at Johns Hopkins University, Baltimore, Maryland; New York University, and Barnes Jewish Hospital, St. Louis, Missouri. Centers in the United Kingdom, Malaysia, and Germany have also performed the surgery using the Heartport system. Half of the procedures have been single CABG and half have been mitral valve replacement.

It should be noted, Dr. Reitz stated, that one patient, a 48-year-old man, recently underwent the first, multiple-bypass procedure at Stanford using the port-access approach. The person left the hospital 60 hours after surgery, roughly half the length of stay commonly seen with traditional procedures.

This information is based chiefly on investigations reported on at the 69th Scientific Sessions of the American Heart Association; New Orleans, Louisiana; November 10-13, 1996; and at the Stanford Symposium on Minimally Invasive Cardiac Surgery; New Orleans, Louisiana; November 14, 1996.

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