Minimally invasive direct coronary artery bypass grafting (MIDCAB) combines the advantages of limited surgical access with the benefits of off-pump coronary artery bypass grafting (CABG). However, this procedure is limited to single-vessel revascularization of the heart and cannot be used in patients with double- or triple-vessel disease. Recently, robotic surgical systems have been developed to enhance the surgeon’s ability and precision. Robotic surgical systems are useful for harvesting the entire length of the bilateral internal thoracic arteries (ITAs) through minimal surgical access. We report on our initial clinical experience with multivessel MIDCAB with robotic assistance for bilateral ITA harvesting.

Case Report

A 54-year-old man with multivessel coronary artery disease was referred to our institution for coronary artery revascularization. Cardiac catheterization revealed severe stenosis of the proximal left anterior descending coronary artery (LAD) and an obtuse marginal branch (OM), and total occlusion of the proximal right coronary artery (RCA). The left ventricular ejection fraction was 58%. MIDCAB with the use of the bilateral ITAs was planned to achieve superior graft patency and to allow the patient an earlier return to work. After giving informed consent, the patient underwent bilateral ITAs harvesting with the da Vinci surgical system (Intuitive Surgical, Inc, Mountain View, CA, USA) and subsequent off-pump CABG through a small left anterior thoracotomy. A catheter of thoracic epidural anesthesia was placed for postoperative pain control on the day before the operation.

After satisfactory establishment of general endotracheal anesthesia with a double-lumen tube to permit selective ventilation, the patient was placed in the supine position with pillows under the left scapula to allow optimal performance of the robotic procedure. The left radial artery (RA) was harvested first, and the patient’s arm was hung on the side supported by sheets. Three 1–2-cm-long incisions were made in the second, fourth, and sixth intercostal spaces slightly medial to the anterior axillary line. After the left lung was deflated, a camera port was inserted through the middle incision, and carbon dioxide insufflation was started and was maintained at an average pressure of 10 mmHg. A 30-degree angle-up camera was inserted. The left and the right instrument ports were inserted under direct vision through the camera. A surgical cart with 3 mechanical arms was attached to the camera and the instrument arm ports. The left ITA was harvested completely in a totally skeletonized fashion by using an electric scalpel to cauterize and transect all branches (Fig 1). The angle-up camera was then exchanged for a 0-degree camera. The mediastinal pleura was dissected from the chest wall, and the right pleural cavity was entered. The right ITA was then harvested in a similar fashion (Fig 2). The required time for left ITA harvesting was 30 min and that for right ITA harvesting was 30 min and that for right ITA harvesting.
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was 36 min. After systemic heparinization, hemostat clips were applied to the distal ends of the bilateral ITAs, which were then transected. The right ITA was routed into the left pleural cavity.

A limited left anterior thoracotomy incision was then made in the fourth intercostal space, extending from the camera port incision toward the sternum for 10 cm. The ends of the grafts were brought through the incision and prepared for anastomosis. The pericardium was incised longitudinally, and pericardial sutures were placed to bring the heart in view for distal coronary anastomoses. An end-to-end anastomosis was established between the right ITA and the RA. The left ITA was anastomosed to the LAD, and the composite RA graft from the right ITA was sequentially anastomosed to the first diagonal branch, the OM, and the distal RCA on the beating heart without having to perform a cardiopulmonary bypass. All distal anastomoses were handsewn using an Acrobat vacuum stabilizer (Guidant, Santa Clara, CA, USA).

The pericardium was loosely closed over the heart, and drains were placed in the bilateral pleural cavities. The left lung was reinflated, and the chest was closed in the usual manner. The total operative time was 5 h 58 min, and no blood products were required.

The endotracheal tube was removed 4 h after the operation. Neither blood products nor inotropic drugs were required. An epidural anesthesia was continued until the patient left the intensive care unit on postoperative day 2. A postoperative angiography revealed that all grafts were widely patent (Fig 3). Fig 4 shows the incision after surgery. The patient was discharged 10 days after the operation, and is free of symptoms 4 months after the operation.

Discussion

A robotic technology that provides 3-dimensional (D) visualization, magnification, and technical dexterity has been applied to perform coronary artery revascularization. In 1999, Watanabe et al reported the first case of the beating-heart endoscopic CABG in the world. Since 2006, we have performed robotically assisted multivessel MIDCAB using the da Vinci surgical system in 3 cases, including the case described in this report. Bilateral ITAs were used for complete revascularization in all cases, and the average number of distal anastomoses was 4 per patient. Recently, several authors have reported further experiences with
robotically assisted CABG. However, the average number of distal anastomoses in their reports, which ranged from 2.2 to 2.6, was lower than the number in our series. Our outcome of 4 anastomoses per patient compares favorably with the number of distal anastomoses in off-pump CABG through a sternotomy.

Single-vessel CABG of the left ITA to the LAD through a small thoracotomy has been shown to produce excellent results with a low mortality rate. However, this procedure has been limited to single-vessel disease because of its technical limitations for harvesting the entire length of left ITA and using grafts other than the left ITA. We have previously reported bilateral MIDCAB with the use of the bilateral ITAs in patients with multivessel disease. The bilateral ITAs were harvested thoracoscopically as a pedicle under 2-D image guidance. Thoracoscopic harvesting of the bilateral ITAs was more difficult than standard ITA dissection through a median sternotomy, and the mean time required for bilateral ITA harvesting was 123 min. With robotic assistance, the time required for bilateral ITA harvesting was significantly reduced to 66 min. Wristed instruments and 3-D visualization of the robotic surgical system enabled quicker and a more precise harvest of the bilateral ITAs. Furthermore, the conduit length is usually longer with robotic ITA harvesting than with conventional endoscopic harvesting because of total skeletonization and better access to the proximal and distal portions of the conduit. Robotic instrumentation allows the entire lengths of the bilateral ITAs to be harvested in a skeletonized fashion, resulting in greater conduit lengths and enabling multivessel grafting.

The ultimate aim of minimally invasive CABG is to perform totally endoscopic off-pump CABG, including coronary anastomosis in a closed-chest environment, for patients with multivessel disease. The first step toward totally endoscopic off-pump CABG was the elimination of the support of the cardiopulmonary bypass and the access trauma of a sternotomy when using conventional CABG (ie, the MIDCAB technique). The next step is the robotically assisted MIDCAB described in this report. We believe that the robotically assisted MIDCAB can be extended to more complex revascularization. Further development of robotic surgical systems and heart positioning devices will allow routine totally endoscopic off-pump CABG.

In conclusion, robotic assistance has allowed the use of the bilateral ITAs through a small thoracotomy. Robotically assisted CABG through a thoracotomy on a beating heart is a safe and effective means of performing myocardial revascularization in patients with multivessel disease. This approach might be an evolutionary step toward totally endoscopic off-pump coronary artery bypass surgery.

References