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Robotic-Enhanced Dresden Technique for Minimally Invasive Bilateral Internal Mammary Artery Grafting

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ABSTRACT

Background: The introduction of robotic-enhanced endoscopic instrumentation systems allows the surgeon to perform arterial revascularization for multivessel coronary artery disease without sternotomy.

Methods: From April 1999, 27 patients (6 female, 21 male, median age 63 ± 8.2 years) suffering from multivessel coronary artery disease were treated surgically using arterial revascularization by means of bilateral internal mammary artery (BIMA) grafting. Both arteries were harvested totally endoscopically using the da Vinci™ robotic surgical system (Intuitive Surgical, Mountain View, CA). These vessels were anastomosed using the "Dresden Technique" via a left minithoracotomy in the second intercostal space.

Results: All patients survived the operation. The mean duration of surgery was 240 ± 79.4 minutes. Bilateral internal mammary artery harvesting time was 88.5 ± 15.9 minutes, and cross-clamp time was 38 ± 10.9 minutes. An average of 2.07 anastomoses were performed per operation. Postoperatively, the patients remained in ICU for 20 ± 2.4 hours. One patient needed reexploration due to bleeding.

Conclusions: Bilateral internal mammary artery harvesting can be achieved safely with the use of wrist-enhanced instrumentation. The robotic surgical system introduces into surgical practice a new type of treatment of coronary artery disease, helping to perform arterial revascularization with a distinctly reduced surgical trauma.

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INTRODUCTION

In recent years, minimally invasive techniques have been introduced into cardiac surgery. In order to reduce the complex surgical trauma of median sternotomy new techniques using small incisions have evolved. In October 1996, at the Cardiovascular Institute at the University of Dresden, Germany, a new minimally invasive technique for the treatment of coronary artery multivessel disease was developed [Gulielmos 1999].

Beginning with a small left-lateral chest incision through a 6–8 cm minithoracotomy in the left second intercostal space, complex coronary procedures have been performed. The patient is put on extracorporeal circulation (ECC) and the operation is performed on an arrested heart. A detailed description of this technique was published previously [Gulielmos 1999]. This method allows a complete arterial revascularization of the coronary system without sternotomy. However, before the installation of a robotic wrist enhanced system at our Institute, it was very difficult to harvest both internal mammary arteries from a small, left lateral chest incision.

The application of a robotic-enhanced, totally endoscopic method allows a safe harvesting of both mammary arteries via three 1 cm left lateral chest incisions. Using this new minithoracotomy access, sternotomy is avoided. This report illustrates our initial experience with this new concept.

MATERIALS AND METHODS

Since the introduction of a wrist-enhanced, 3-D based robotic system at our Institute in May 1999, 119 patients (86 male, 33 female, median age 63 ± 10.3 years) have been successfully treated using the system. Twenty-seven patients (6 female, 21 male, median age 63 ± 8.2 years) suffering from multivessel coronary artery disease were treated using the

Table 1. Pre,- peri-, and postoperative data

Technique	REDTCAB (n=27)
SVD/DVD/MVD	2/24/1
Sex	6 female, 21 male
Age (years)	63 ± 8.2
Height (cm)	169 ± 6.9
Weight (kg)	74 ± 9.6
EF (%)	68 ± 10.1
LVEDP (mm Hg)	14 ± 6.8
Duration of surgery (min)	240 ± 79.4
LIMA take down (min)	40 ± 13
RIMA take down (min)	45 ± 15.4
BIMA take down (min)	87 ± 18.1
Cross-clamping (min)	38 ± 10.4
Ventilation time (h)	3.5 ± 13.6
ICU stay (h)	20 ± 24
Hospital stay (d)	7 ± 1

n = number of patients, REDTCAB = Robotic-Enhanced Dresden Technique Coronary Artery Bypass, SVD/DVD/MVD = Single-, Double- and Multi-Vessel Coronary Artery Disease, EF = Ejection Fraction, LVEDP = Left Ventricular Enddiastolic Pressure, LIMA = Left Internal Mammary Artery, RIMA = Right Internal Mammary Artery, BIMA = Bilateral Internal Mammary Artery, ICU = Intensive Care Unit.

Table 2. Vessels affected by coronary artery disease and conduits used

Technique	Revascularization scheme and conduits used
REDTCAB (n=27)	LIMA-OM, RIMA-LAD (n=10)
	LIMA-LAD, RIMA-RCA (n=9)
	LIMA-DB-LAD jump, RIMA-RCA (n=2)
	LIMA-OM, RIMA-LAD, ACVB-DB (n=1)
	LIMA-IB, RIMA-LAD (n=1)
	LIMA-OM, RIMA-LAD (n=1)
	LIMA-LAD, ACVB-IB (n=1)
	LIMA-LAD, ACVB-DB (n=1)
	LIMA-DB, RIMA-LAD (n=1)

n = number of patients, REDTCAB = Robotic-Enhanced Dresden Technique Coronary Artery Bypass, LAD = Left Anterior Descending, LIMA = Left Internal Mammary Artery, DB = Right Diagonal branch, RIMA = Right Internal Mammary Artery, RCA = Right Coronary Artery, IB = Right Intermediate branch, OM = Obtuse Marginal

robotic-enhanced Dresden Technique (REDTCAB). In all of these patients, both internal mammary arteries were dissected totally endoscopically using the robotic system, and the operation was further conducted applying the minimally invasive “Dresden Technique” [Gulielmos 1999].

Technique of endoscopic harvesting of bilateral internal mammary arteries (BIMA)

The patient is intubated with a double lumen ventilation tube allowing single lung ventilation. The patient is in supine position with a 30° left chest elevation, with the left arm attached to the body below the midaxillary line. Following skin disinfection and sterile draping, the camera port is introduced in the fifth intercostal space (ICS) in the anterior axillary line. After initiation of single lung ventilation and connection of CO_2 insufflation, the 3-D endoscope is introduced into the chest cavity for preliminary exploration. The robot is then positioned on the right side of the patient in order to connect the camera actuator of the robot to the camera port.

The two other ports for instrumentation, localized in the third (right arm) and sixth (left arm) ICS in the medioclavicular line, are then introduced. The left internal mammary artery is first exposed in full length from the first rib down to the bifurcation. Further harvesting of the left mammary artery (LIMA) will be continued after the dissection of the right internal mammary artery (RIMA).

The right pleural cavity is entered at the level of the second or third ICS. After a broad opening of the pleura, the RIMA is exposed. Because of a continuous CO_2 insufflation, the right lung does not expand completely during inspiration, thus leaving a 2–3 cm space for a safe harvesting of the RIMA. Despite this reduced lung capacity, the patient’s oxygenation is not disturbed. At this point, the 30° endoscope is replaced by a 0° 3-D endoscope. Dissection is started medially to the RIMA in a manner well known from conventional harvesting techniques. Having completed the dissection of both internal mammary arteries, the vessels are clipped and detached from the sternum (Movie 1, ◉).

Robotic-Enhanced Dresden Technique Coronary Artery Bypass (REDTCAB)

After completion of endoscopic BIMA harvesting, the robotic system is removed. In all cases, a 6–8 cm parasternal minithoracotomy in the second ICS of the left chest was chosen for surgical access. The second and third ribs are temporarily detached from the sternum. After introduction of a small tissue retractor, the harvested BIMA are then retrieved from the chest and spatulated for anastomosis (Figure 1, ◉).

The pericardial fat is dissected, the pericardium is opened longitudinally, and stay sutures are placed. Venous drainage for extracorporeal circulation is secured by a percutaneous venous cannula via the right femoral vein. The ascending aorta is directly cannulated via the second ICS incision, as is likewise the cardioplegic line. Extracorporeal circulation was initiated then. After achieving a cardiac index of approximately 2.5 L/min/m^2, the ascending aorta is cross-clamped with a conventional clamp and cardioplegic solution is introduced into the aortic root.

During cardioplegic arrest, aortic root venting is performed and the arrested heart can be rotated using a gauze sling. Using this single tool, every targeted area of the heart can be exposed and the target vessels grafted. End-to-side anastomoses are performed between the harvested BIMA and the coronary arteries in a standard fashion. Before removing the aortic clamp, antegrade deairing is performed through the ascending aorta. The cross-clamp is removed and the patient is weaned from ECC. The cannulas are removed from the aorta and from the femoral vein. Both ribs are reattached to the sternum. Each pleural cavity is drained separately by a soft chest drain (Movie 2, ◉).

RESULTS

Survival was 100%. All patients left the operating room without inotropic support, in sinus rhythm and without signs of acute myocardial ischemia.

The application of the wrist-enhanced robotic system results in a reduction of surgical trauma to the chest wall. Sternotomy is no longer necessary to obtain two excellent arterial grafts for myocardial revascularization, and there is no extensive pulling or traction on the IMA.

Due to the avoidance of median sternotomy and due to endoscopic BIMA harvesting, longer conduits could be harvested, thus enabling revascularization of all targeted areas of the heart. Sequential grafting is also possible (Table 2, ◉).

Preoperative, perioperative, and postoperative data are presented in Table 1 (◉). The average number of grafted vessels amounted to 2.07 per patient. LIMA harvesting took 40 ± 13 minutes, while RIMA dissection was a bit longer at 45 ± 15.4 minutes. The aorta was cross-clamped for 38 ± 10.9 minutes, and total time for surgery was 240 ± 79.4 minutes.

Single lung ventilation was started shortly before introducing the camera port into the left chest cavity. In this manner, the patients were ventilated throughout BIMA dissection.

DISCUSSION

The introduction of small chest incisions for cardiac surgery and the application of new technologies has changed the treatment of coronary artery disease (CAD). With the installation of a wrist-enhanced surgical system, the minimally invasive surgical treatment of CAD using computer enhanced surgical techniques was significantly improved [Falk 2000, Kappert in press 2000a, Kappert in press 2000b, Loulmet 1999, Mohr 1999, Reichenspurner 1999].

The treatment of multivessel coronary artery disease using endoscopically harvested bilateral internal mammary arteries became a reality. The initially developed Dresden Technique (Gulielmos 1999, Gulielmos 1998) for the treatment of multivessel disease was upgraded to REDTCAB by the use of the robotic system, which permits BIMA dissection and total arterial revascularization for multivessel CAD.

The new features of the da Vinci™ system (Intuitive Surgical, Mountain View, CA) make it a very welcome next-generation tool. It should be emphasized that a general advantage of this computerized device arises on the one hand from the 6° of freedom of motion it provides and on the other hand from an optimized 3-D visualization. Some additional features, such as a moving camera system, motion scaling, tremor elimination, and ergonomically aligned manipulators at the master console, further facilitate a swift reduction of the adaptational period for BIMA harvesting with the system.

With REDTCAB, the treatment of multivessel CAD without sternotomy is a safe procedure, allowing total arterial revascularization using BIMA with an excellent cosmetic outcome (Figure 2, ◉).

This new approach for the minimally invasive treatment of patients with multivessel coronary artery disease appears to be a superior procedure to the standard technique and may soon achieve a more widespread application, especially in patients with risk factors for sternotomy-related morbidity.

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