Surg Today (2007) 37:944–946
DOI 10.1007/s00595-007-3542-4

SURGERY TODAY

Original Articles

Robotic Internal Thoracic Artery Harvesting

NORIHIKO ISHIKAWA[1], GO WATANABE[2,3], KENJI IINO[2], SHIGEYUKI TOMITA[2], SHOJIRO YAMAGUCHI[2], KOICHI HIGASHIDANI[2], KENJI KAWACHI[3], and NORIYUKI INAKI[1]

Departments of [1]Telesurgery and Geomedicine and [2]General and Cardiothoracic Surgery, Kanazawa University School of Medicine, 13-1 Takara-machi, Kanazawa 920-8641, Japan
[3]Department of Cardiac Surgery, Tokyo Medical University, Tokyo, Japan

Abstract
Purpose. Great progress has been made in robotic surgery, and several reports on robot-assisted coronary artery bypass grafting (CABG) have been published. Our team at Kanazawa University began using the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) in 2005. We report our experience of using the da Vinci Surgical System for totally endoscopic internal thoracic artery (ITA) harvesting.
Methods. Between December 2005 and May 2006, we used the da Vinci Surgical System to harvest the ITA through three ports placed on the left side of the chest in 10 patients.
Results. All 10 ITAs were harvested successfully in a skeletonized fashion. The robotic harvesting time was reasonable at 38.8 ± 25.2 min, and the average length of harvested ITA was 16.2 ± 3.1 cm. After computer-enhanced ITA harvesting, seven patients underwent off-pump CABG and three patients underwent minimally invasive direct CABG. There was no mortality, and the postoperative patency rate of all grafts was 100%.
Conclusions. The da Vinci Surgical System provides a high-resolution stereoscopic image and allows remote, tremor-free, and scaled control of endoscopic surgical instruments with seven degrees of freedom. Computer-enhanced ITA harvesting was performed safely with excellent results.

Key words Robot · Internal thoracic artery · Da Vinci Surgical System

Reprint requests to: N. Ishikawa
Received: August 3, 2006 / Accepted: March 3, 2007

Introduction

Remarkable developments have been made in the robotic surgical technology to reduce surgical trauma and to improve the postoperative course. Several reports on robot-assisted coronary artery bypass have been published, but the technique used for left internal thoracic artery (LITA) harvesting remains controversial.[1,2] We began using the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) in December 2005. Before the introduction of this system, we had performed totally endoscopic ITA harvesting and reported its safety.[3] Here, we evaluate the feasibility and potential benefits of robotic ITA harvesting.

Patients and Technique

Between December 2005 and May 2006, we used the da Vinci Surgical System in two ways for coronary artery bypass grafting (CABG) in 10 patients: to harvest the ITA, followed by a minimally invasive direct CABG in three patients; and to harvest the ITA, followed by off-pump CABG in seven patients (Table 1).

After the induction of anesthesia, a double-lumen endotracheal tube was introduced to permit alternative left lung collapse. The patients were then placed supine with the left side of the chest elevated approximately 30° and the left hand placed beneath the posterior axillary line. A 12-mm robotic camera port was inserted through the fourth intercostal space (ICS) along the anterior axillary line on the left side of the chest. CO2 insufflation was used to maintain an insufflation pressure of 6–12 mmHg before introducing the da Vinci system endoscope. After identifying the LITA, two other instrument ports (8 mm) were created, under endoscopic vision, in the second ICS on the anterior axillary line and in the sixth ICS on the midclavicular line. The LITA was dissected with the aid of a 30°-up

Table 1. Patients' characteristics and results

Patient no.	Sex	Age (years)	ITA harvesting time (min)	Length of LITA (cm)	Post-ITA harvesting procedure
1	M	67	33	—	OPCAB
2	M	60	112	—	OPCAB
3	M	73	28	13	OPCAB
4	M	63	29	15	OPCAB
5	M	66	35	—	MIDCAB
6	M	56	46	20	OPCAB
7	M	64	32	14	OPCAB
8	M	50	26	14	MIDCAB
9	M	61	22	—	MIDCAB
10	M	72	25	21	OPCAB

ITA, internal thoracic artery; LITA, left ITA; M, male
OPCAB, off-pump CABG; MIDCAB, minimally invasive direct CABG; CABG, coronary artery bypass grafting

endoscope. The skeletonized harvesting technique was similar to that used in open surgery or endoscopy: Blunt and sharp dissections were performed with an EndoWrist spatula cautery (Intuitive Surgical) on one robotic arm and the EndoWrist deBakey forceps (Intuitive Surgical) on the other robotic arm. The LITA was harvested from the adhesion site of the first rib to the first bifurcation of the sixth rib, and the branches were coagulated or clipped endoscopically. After completion of the dissection and general heparinization, the distal extremity of the LITA was transected and an atraumatic vascular clamp was placed on the artery.

Results

All 10 ITAs were harvested successfully in a skeletonized fashion (Table 1). Only one patient (no. 2) suffered intraoperative hypotension, defined as a systolic blood pressure of less than 50 mmHg. The camera port in this patient was placed more lateral to the anterior axillary line, and CO2 insufflation was increased to 18 mmHg to maintain the surgical field. After emergency desufflation, the patient's hemodynamics stabilized quickly, and the procedure continued under 14 mmHg CO2 insufflation. Consequently, it took 112 min to harvest the ITA in this patient. Nevertheless, the total mean robotic harvesting time was still reasonable, at 38.8 ± 26.15.2 min. The average length of the harvested ITA was 16.2 ± 3.1 cm in six patients. After robotic ITA harvesting, seven patients underwent off-pump coronary artery bypass via sternotomy and three patients underwent minimally invasive direct coronary artery bypass via minithoracotomy. The overall early mortality in this cohort of 10 patients was 0% and the postoperative patency rate of the grafts was 100%.

Discussion

The da Vinci Surgical System provides a high-resolution stereoscopic image and allows remote, tremor-free, and scaled control of endoscopic surgical instruments with seven degrees of freedom. Its technological advantage has created new options for minimally invasive cardiac surgery.[4,5] There are several reports of robotic ITA harvesting procedures, including robotic bilateral ITA harvesting and robotic coronary artery anastomosis.[1] However, the techniques for robotic ITA harvesting have not been described in detail, and the ideal positioning of ports must be considered preoperatively. Recently, we obtained preoperative three-dimensional computer tomography images taken with the patient in the same position as planned for robotic ITA harvesting, and evaluated various port positions for harvesting the ITA from the first rib to the sixth rib (Fig. 1). If the right instrument port is placed more caudal than necessary, the right robotic instrument cannot reach the proximal side of the ITA because the right robotic arm and the robotic camera arm are too close. The camera port must not be placed laterally in the chest because the heart obstructs the surgical view, even if an endoscope is being placed 30° up. Consequently, the right instrument ports and the camera port are often placed in the second and fourth ICS on the anterior axillary line. This is very important in patients with a small physique, as is common among Japanese. There is one more technique to avoid conflict between the right arm and the camera arm. When the surgeon sets up the robot, it is necessary to face the elbow of the robot arm toward the outside as much as possible (Fig. 2). Furthermore, CO2 insufflation effectively maintains an excellent working space in the thoracic cavity during the procedure, but we assume its upper limit to be 16 mmHg.

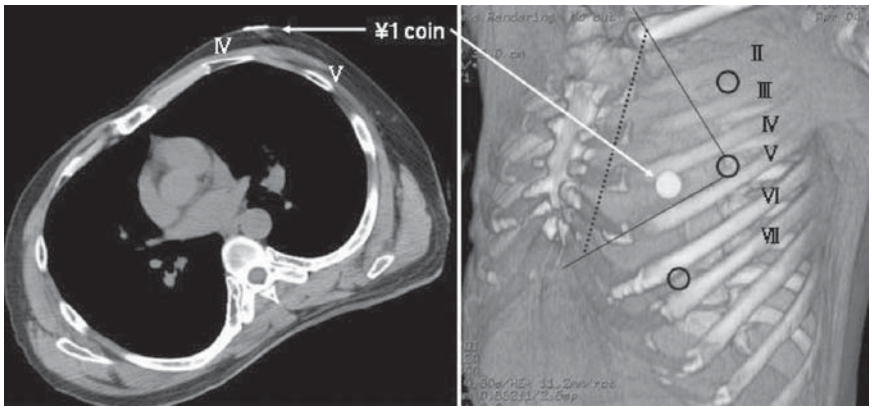

Fig. 1. Preoperative three-dimensional computer tomography image showing the port positions. To assist in determining the correct position of the ports intraoperatively, a 1-yen coin was placed over the left nipple

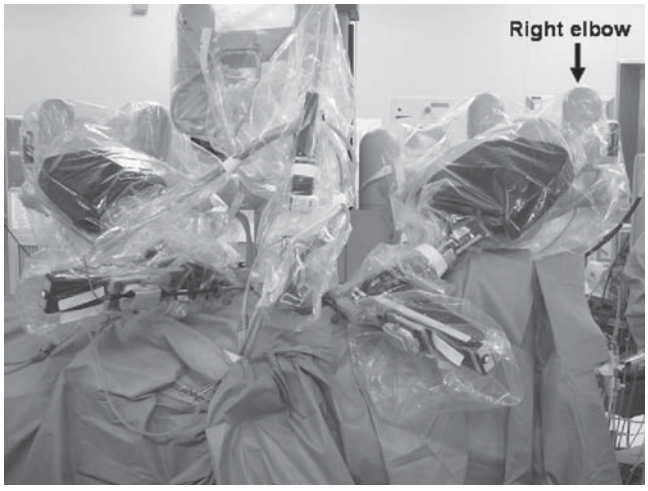

Fig. 2. Positioning of the da Vinci surgical system for robotic internal thoracic artery harvesting. It is very important to face the elbow of the robot arm toward the outside as much as possible to avoid conflict between the robotic arm and the camera arm

Endoscopic and robotic ITA harvesting requires greater opening of the left pleural cavity, which may cause pleural adhesions. However, these procedures do not require long incisions or extended sternotomy because the ITA has already been harvested. Consequently, patients gain a cosmetic advantage, and postoperative wound pain is minimized. We reported the safety of endoscopic ITA harvesting in a previous series of 22 patients, in which the mean harvesting time was 53 min without any complications. Comparing the endoscopic and robotic procedures, robots can harvest a longer ITA more safely and quickly. In robotic procedures, the proximal site of harvesting is the first rib, which is sometimes the bifurcation with the left subclavian artery. Cost is a disadvantage of the robotic procedure. Robotic ITA harvesting uses three robotic instruments, incurring a total cost of about US$1 500, including the sterilized drapes, for each procedure.

In conclusion, we performed robotic ITA harvesting using the da Vinci Surgical System safely, with excellent results.

References

1. Robin J, Bompard D, Tronc F, Beaune J, Wahid F, Champsaur G. Bilateral internal thoracic artery harvesting under robotic videoassistance. Surg Endosc 2001;15:755–6.
2. Boyd WD, Kodera K, Stahl KD, Rayman R. Current status and future directions in computer-enhanced video- and robotic-assisted coronary bypass surgery. Semin Thorac Cardiovasc Surg 2002;14: 101–9.
3. Tomita S, Watanabe G. Totally endoscopic internal thoracic artery harvesting. Innovations 2006;1:243–6.
4. Menkis AH, Kodera K, Kiaii B, Swinamer SA, Rayman R, Boyd WD. Robotic surgery, the first 100 cases: where do we go from here? Heart Surg Forum 2004;7:1–4.
5. Chitwood WR Jr, Nifong LW. Minimally invasive videoscopic mitral valve surgery: the current role of surgical robotics. J Card Surg 2000;15:61–75.