

Endoscopic Radial Artery Harvesting for Coronary Artery Bypass Grafting: The Initial Clinical Experience and Results of the First 50 Patients

Nobuhisa Ito, MD, Tadashi Tashiro, MD, Noritsugu Morishige, MD, Hidehiko Iwahashi, MD, Masaru Nishimi, MD, Yoshio Hayashida, MD, Kazuma Takeuchi, MD, Noritoshi Minematsu, MD, Go Kuwahara, MD, Yuta Sukehiro, MD

Department of Cardiovascular Surgery, Fukuoka University School of Medicine, Fukuoka, Japan

ABSTRACT

Background: The radial artery (RA) is a commonly used arterial conduit in coronary artery bypass grafting (CABG). Traditional open-vessel harvest often leads to postoperative wound complications and cosmetic problems. Endoscopic RA harvesting (ERAH) has been widely used to prevent these problems. The purpose of this study was to assess these problems and graft patency in the first 50 patients who underwent ERAH.

Methods: Between February 2006 and October 2007, 50 patients underwent ERAH with the VasoView system (Boston Scientific). These patients were compared with 50 patients who underwent the traditional open technique.

Results: The mean age was 62.8 years in both groups. All RAs were successfully harvested. No conversion was made from ERAH to the traditional open technique. The mean harvesting time (forearm ischemic time) was 27.4 ± 6.5 minutes, and the mean length of the RA in the ERAH group was 18.5 cm. Neither wound complications, such as wound infection and skin necrosis, nor severe neurologic complications were recorded. The patency rate was 95.9% (95/99) in the ERAH group and 94% (94/100) in the open group.

Conclusion: ERAH can be performed safely, and the early results are satisfactory. Endoscopic vessel harvesting is therefore recommended as the technique of choice for RA harvesting.

INTRODUCTION

Use of the radial artery (RA) as a conduit for coronary artery bypass grafting (CABG) was first introduced by Carpentier et al [1973], but it was abandoned after reports suggesting a low patency rate [Carpentier 1975]. Acar et al [1992] reintroduced the RA as a viable conduit for CABG, and the RA graft has become popular, with good results having been reported [Roysse 2000].

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Correspondence: Nobuhisa Ito, 7-45-1 Nanakuma, Jonanku, Fukuoka 814-0180, Japan; 81-92-801-1011 (ext 3455); fax: 81-92-873-2411 (e-mail: noby.ito@nifty.ne.jp).

The RA is usually harvested via an open technique. The traditional open technique has often produced cosmetic problems and postoperative wound complications. In 2000, endoscopic vessel harvesting (EVH) devices were introduced and have been available in Japan since November 2003; however, because of the high cost of these devices, technical difficulties, and the fact that this procedure is still not covered by national insurance in Japan, such EVH procedures represent only a small percentage of all CABG procedures performed in Japan.

This new procedure is considered ideal because there is less muscle and tissue damage from harvesting the graft. This procedure may also eliminate many of the complications associated with traditional harvesting. The purpose of this study was to assess these problems and graft patency in the initial 50 patients who underwent EVH.

MATERIALS AND METHODS

Patient Selection

Between February 2006 and March 2008, 175 patients underwent CABG in our institution. Fifty patients underwent an endoscopic RA harvesting (ERAH) procedure with the VasoView System (version 4; Boston Scientific, Natick, MA, USA) (Figure 1). We started using this system in December 2005.

The RA was usually chosen as the graft for patients who were younger than 75 years of age and who did not have chronic kidney disease (serum creatinine >1.5 mg/dL). All patients underwent the preoperative Allen test and preoperative ultrasound evaluation to assess their vessels. If the Allen test was positive, the RA diameter was <2 mm, or the RA had extensive calcification, we did not use the RA as a graft.

The patients were evaluated for postoperative neurologic and wound complications, such as numbness, loss of motor function, infection, and hematoma.

As a control group (open group), we selected 50 consecutive operations that had been performed with the traditional open technique just prior to the introduction of the ERAH technique (August 2003 to November 2005).

Endoscopic Harvesting

All radial arteries were harvested from the nondominant arm by a single surgeon. A 2.5-cm longitudinal skin incision

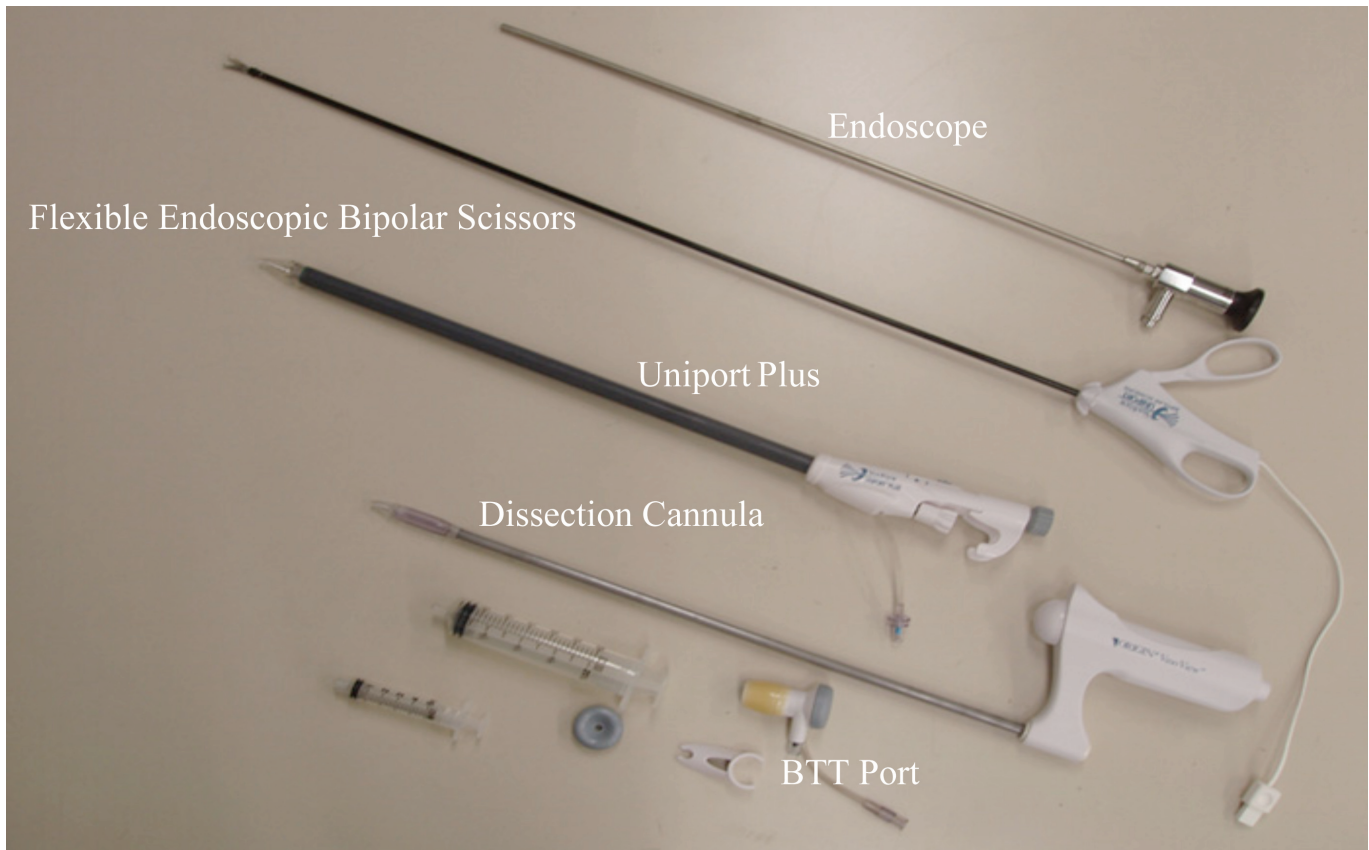


Figure 1. VasoView Endoscopic Harvesting System.

was made approximately 2 cm proximal to the skin crease of the wrist and overlying the radial pulse. After exposing the RA along with its satellite veins, we used electrocautery to perform dissection under direct vision so as not to damage the superficial radial nerve. After intravenous sodium heparin (3000 units) was administered, the forearm was wrapped from the distal to the proximal side with an Esmarch bandage, and the tourniquet was inflated to 250 mm Hg. The Esmarch bandage was then released. After insertion of the BTT port (short port blunt tip trocar), carbon dioxide was applied at a pressure of 12 cm of H₂O. We inserted the dissection cannula along the entire vascular bundle and dissected the RA, taking care not to tear off the satellite veins. Bipolar electrocautery was used for branch ligation. After proximal ligation, the RA was removed, flushed, and stored in heparinized saline containing olprinone hydrochloride hydrate (one of the phosphodiesterase III inhibitors).

Use of the RA

First, we used a harmonic scalpel to skeletonize the RA and the satellite veins that were harvested endoscopically. We have used pedicled grafts since late 2006. The conventional open technique was performed entirely with the harmonic scalpel for skeletonization.

The RA was used in the aortocoronary (AC) position, or if the RA was used as a composite, it was used in a Y, I, or inverted-T fashion [Tashiro 1999].

Assessment of Graft Patency

In most patients, postoperative coronary angiography or 3-dimensional computed tomography was performed before discharge. Anastomotic failure was defined as occlusion or stenosis of >75%. The presence of extensive conduit narrowing was considered functional occlusion, and such a graft was recorded as nonpatent.

Statistics

The data are presented as the mean \pm SD or as percentages. Differences between groups were analyzed with the paired Student *t* test for continuous variables and with the χ^2 test or the Fisher exact test for dichotomous variables, as appropriate. *P* values <.05 were considered to indicate statistical significance. Data were analyzed with the StatView software program (version 5.0 for Windows; SAS Institute, Cary, NC, USA).

RESULTS

Table 1 summarizes the details of the patient characteristics and operations. The mean age of the patients who participated in this study was 62.8 years. There were no significant differences between the groups with respect to preoperative conditions such as hypertension, hyperlipidemia, or diabetes. In addition, there were no significant differences in the

Table 1. Patient Characteristics and Operative Data*

	ERAH (n = 50)	Open (n = 50)	P
Age, y	62.8 ± 9.1	62.8 ± 9.4	.8413
Height, cm	163.6 ± 7.6	161.3 ± 8.3	.1560
Body surface area, m ²	1.7 ± 0.1	1.6 ± 1.1	.1960
Male/female sex, n	42/8	41/9	.7901
Hypertension	66%	78%	.1814
Diabetes mellitus	52%	56%	.6882
Hyperlipidemia	74%	64%	.2797
Prior cerebrovascular accidents	8%	16%	.3567
Old myocardial infarction	32%	40%	.4047
LVEF, %	59.5 ± 12.9	62.8 ± 11.6	.1624
EuroSCORE	3.8 ± 2.5	3.5 ± 2.1	.4973
Isolated CABG, n	46 (92%)	47 (94%)	>.9999
Off pump	45 (90%)	30 (60%)	.0005
On pump (beating heart)	1 (2%)	2 (4%)	>.9999
On pump (cardiac arrest)	0 (0%)	15 (30%)	<.0001
Concomitant procedures, n	4 (8%)	3 (6%)	>.9999
Valve procedure	0	1	>.9999
Coronary aneurysm repair	1	1	>.9999
Left ventricular restoration	2	0	.4949
Others	1†	1‡	>.9999
Total operative time, h	5.8 ± 1.2	5.7 ± 2.1	.1906
Use of internal thoracic artery	100%	96%	.4949
No. of distal coronary anastomoses, /patient			
Total	4.4 ± 1.1	3.6 ± 1.0	.0005
RA	2.1 ± 0.8	2.0 ± 0.8	.5496
Length of RA graft, cm	18.5 ± 1.5	16.8 ± 1.3	<.0010
Use of RA			
AC position	84%	54%	.0012
Y composite	6%	8%	>.9999
I composite	8%	24%	.0538
Inverted T	2%	14%	.0594
Intraoperative blood loss, g	400 ± 299	388 ± 314	.8470
Transfusion	40%	42%	.8389

*Data are presented as the mean ± SD where indicated. ERAH indicates endoscopic radial artery harvesting; LVEF, left ventricular ejection fraction; CABG, coronary artery bypass grafting; RA, radial artery; AC, aortocoronary.

†Pulmonary vein isolation.

‡Total arch replacement.

EuroSCORE, the left ventricular ejection fraction, and the presence of old myocardial infarction. Although there were no differences between the groups in the ratios of concomitant procedures, the off-pump ratio was significantly higher in the ERAH group.

Table 2. Clinical Results and Complications Associated with Endoscopic Radial Artery Harvesting (ERAH)

	ERAH (n = 50)
Length of incision, cm	2.5
Additional incision, n	0
Harvesting time (forearm ischemia time), min	27.4 ± 6.5
Conversion to open harvesting, n	0
Loss of grafts for injury, n	0
Unusable grafts, n	0
Hematoma, n	0
Induration, n	0
Infection, n	0
Skin necrosis, n	0
Pain (area of incision), n	1 (2%)
Neurologic complication, n	0

The number of bypasses per patient was 4.4 ± 1.1 in the ERAH group and 3.6 ± 1.0 in the open group. Multivessel bypass was more often performed in the ERAH group, but total operative times were similar. There was also no difference in the number of distal coronary anastomoses with RA grafts (ERAH group, 2.1 ± 0.8; open group, 2.0 ± 0.8). The RA was commonly used at the AC position in the ERAH group.

Details of the ERAH group are shown in Table 2. In the ERAH group, the length of the forearm skin incision was 2.5 cm in all cases, and the mean forearm ischemic time (time of endoscopy) was 27.4 ± 6.5 minutes. Although there was no difference between the 2 groups with respect to height or body surface area, we were able to harvest a significantly longer graft in the ERAH group. There was no significant damage to the graft, and all RA grafts were usable.

In the ERAH group, there was no wound infection or subcutaneous hematoma requiring additional operation, and there was no case of serious nerve damage. One patient, however, complained of pain in the area where the incision had been made, and the symptoms persisted for 1 year after the operation.

Postoperative morbidity and mortality data are summarized in Table 3. There was no significant difference in postoperative morbidity, such as perioperative myocardial infarction, reexploration for bleeding, and mediastinitis, and there was no difference in the length of stay in the intensive care unit; however, the length of the hospital stay was significantly shorter in the ERAH group.

Early Graft Patency Rate

Postoperative angiography was performed in 47 of 50 patients (94%) in the ERAH group and 48 of 50 patients (96%) in the open group (Table 4). The 2 groups were similar with respect to the patency rates of RA grafts (ERAH group, 95.9% [95/99]; open group, 94.0% [94/100]). Even when we compared the rates by target vessel, the patencies were similar.

Table 3. Postoperative Morbidity and Mortality*

	ERAH (n = 50)	Open (n = 50)	P
Death, n	0	0	—
Perioperative myocardial infarction, n	0	0	—
Atrial fibrillation, n	4 (8%)	11 (22%)	.0905
Cerebrovascular accidents, n	0	1 (2%)	>.9999
Reexploration for bleeding, n	1 (2%)	0	>.9999
Length of ICU stay, d	1.4 ± 0.9	2.5 ± 8.1	.8882
Hospital stay, d	21.5 ± 10.6	30.8 ± 30.0	.0476

*Data are presented as the mean ± SD where indicated. ERAH indicates endoscopic radial artery harvesting; ICU, intensive care unit.

Table 4. Early Graft Patency Rates*

	ERAH (n = 47)	Open (n = 48)	P
Total (RA)	95.9% (95/99)	94.0% (94/100)	.7475
LAD	100% (3/3)	100% (11/11)	>.9999
Dx	96.6% (29/30)	90.0% (18/20)	.5561
LCX	95.2% (60/63)	94.8% (55/58)	>.9999
RCA proximal (#1-#3)	—	100% (1/1)	—
PDA	100% (3/3)	90.0% (9/10)	>.9999

*ERAH indicates endoscopic radial artery harvesting; RA, radial artery; LAD, left anterior descending artery; Dx, diagonal branch; LCX, left circumflex artery; RCA, right coronary artery; PDA, posterior descending artery.

DISCUSSION

In CABG surgery, the left internal thoracic artery yields good long-term patency for anastomosis to the left anterior descending artery, with features that have a positive effect on the survival rate [Loop 1986; Cameron 1996]. In addition, the use of both internal thoracic arteries has been reported to be better for long-term survival than the use of the artery from just one side [Buxton 1998; Lytle 1999; Taggart 2001]; however, the use of both internal thoracic arteries may increase the risk of mediastinitis, besides increasing the time required to harvest the grafts [Parisian Mediastinitis Study Group 1996; Borger 1998].

On the other hand, the RA can be harvested safely and simultaneously with the internal thoracic artery [Royce 1999; Siminelakis 2004], and the thick wall and large vascular diameter of the RA both facilitate anastomosis. Since 1992, when Acar et al reported their good patency results, the use of the RA has increased rapidly. We initiated our use of the RA graft in 1996.

In the past, conventional harvesting was accomplished by means of an electrocautery or harmonic scalpel with an incision from the wrist to the elbow; however, we encountered cosmetic problems and nerve damage due to damage to the

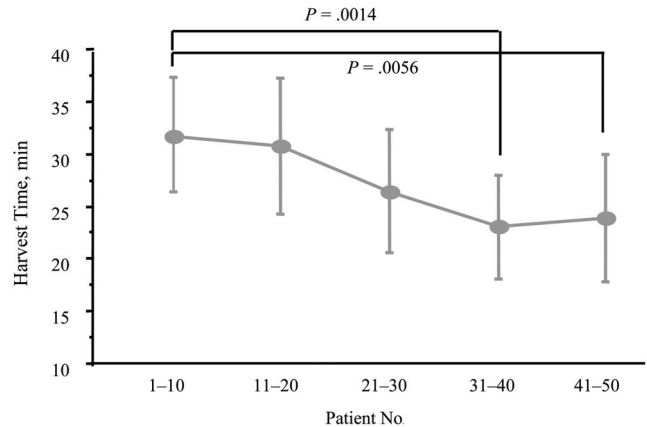


Figure 2. Learning curve: mean harvest time versus number of cases. Harvest time was significantly shorter after 30 cases than for the initial 10 cases.

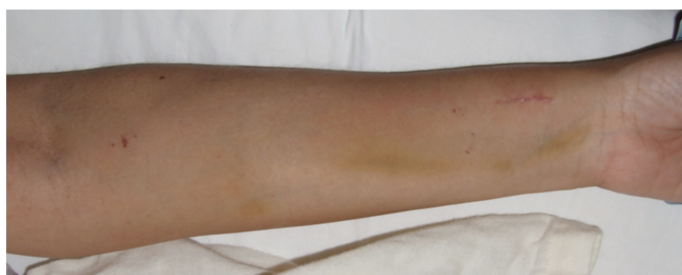
superficial branch of the radial nerve and the lateral antebrachial cutaneous nerve. The frequency of neurologic complications with the conventional method has been reported to range from 11% to 70% [Saeed 2001; Moon 2004; Knobloch 2005].

RA graft may be endoscopically harvested simultaneously with harvesting of the internal thoracic arteries, which is performed conventionally. The smaller skin incision for endoscopy reduces direct nerve injury associated with the skin incision of the open technique, and the use of bipolar electrocautery causes less damage to the surrounding tissues. In addition, the cosmetic results are improved with endoscopic surgery, as has been indicated in recent studies [Patel 2004; Rudez 2007].

When performing the ERAH procedure, the following must be considered: (1) It takes time to acquire the skills to perform the procedure; (2) there is the possibility of not being able to harvest grafts of sufficient length; and (3) grafts may be damaged during harvesting. As was shown in this study, the learning curve is not too long, such that after completing 20 cases, a surgeon can perform the ERAH procedure within 20 to 30 minutes (Figure 2). With further experience, the harvesting time becomes more consistent. In addition, ERAH allowed the harvesting of conduits with a more appropriate length than obtained with the conventional method, even though there were no significant differences in physical characteristics between the 2 patient groups. Some authors have reported no histologic differences between grafts obtained by ERAH and grafts obtained by the conventional method [Shapira 2006]. We compared the patency rates of endoscopically harvested and conventionally harvested RA grafts instead of comparing histologic findings. The patency rates were 95.9% in the ERAH group and 94.0% in the open group (difference not statistically significant), and there were no differences in patency rates when the group patencies were compared by coronary arterial territories. One can conclude that the ERAH group demonstrated a graft performance with regard to patency



7 postoperative days
63-year-old male
Open harvesting technique



7 postoperative days
55-year-old female
ERAH technique



3 postoperative months
72-year-old female
ERAH technique

Figure 3. Comparison of postoperative scars.

that is equivalent to that of the conventional group; however, the data are limited regarding the long-term prognosis, so long-term follow-up with diagnostic imaging will be necessary.

Possati et al [2003] and Tatoulis et al [2004] have reported excellent late results with respect to graft patency for the RA in the AC position. In addition, since the introduction of Enclose® II Anastomosis Assist Device (Novare Surgical Systems, Cupertino, CA, USA), proximal anastomoses without side-clamping at the ascending aorta have become possible; thus, the use of the RA graft in the AC position has become our primary choice.

In our institution, we use the RA graft in 30% to 40% of CABG cases. Patients with the RA graft as a second arterial graft have achieved a good cardiac death-free survival rate (93% at 10 years) [Ito 2008]; therefore, we prefer to use the RA graft routinely for young patients when harvesting of the RA is possible. We also consider the endoscopic technique to offer significant innovation, which enables us to harvest useful artery grafts less invasively (Figure 3).

At present, this endoscopic device is not covered by the Japanese insurance system; consequently, it is used by very few facilities. Use of this device, however, also facilitates harvesting great saphenous vein grafts from the same patient, as well as harvesting both RA and saphenous vein grafts.

As this study has indicated, it is clear that ERAH is a better method than the traditional method for graft harvest, because of the infrequent occurrence of complications

and the excellent patency rate of the grafts. Similar excellent data have been reported for endoscopic harvesting of the great saphenous veins [Allen 1998; Crouch 1999]. In addition, we determined that the postoperative hospital stay was significantly shorter for ERAH patients than for those who underwent RA graft harvesting with the traditional method.

We intend to continue to study the long-term performance of RA grafts harvested endoscopically.

CONCLUSION

We studied the early results of ERAH. There were fewer postoperative complications, and we obtained satisfactory cosmetic results. In addition, the patency rate was comparable to that of the traditional method.

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