

## Endoscopic Radial Artery Harvesting: Our Initial Experience and Results of the First 25 Patients

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**Background:** The radial artery has become an increasingly popular arterial conduit for coronary artery bypass grafting (CABG). However, the traditional open harvesting technique requires a long incision, and is therefore associated with some wound complications and cosmetic problems. Here, we describe our experience of endoscopic radial artery harvesting (ERAH) through a small incision in 25 patients who underwent CABG.

**Materials and Methods:** Between February 2, 2004 and January 7, 2005, a total of 25 patients (4 females; mean age: 64±10 years) underwent ERAH using the VasoView System (Guidant Corporation, Indianapolis, IN) at our institution. All patients underwent a preoperative Allen test to assess the competence of the palmar arch. Twenty-four radial arteries were harvested from the nondominant arm and one from the dominant arm. The mean clinical follow-up was 8±2.9 months.

**Results:** All radial arteries were harvested through a 2-cm incision at the wrist, successfully removed with ERAH and successfully used as CABG conduits. The mean harvest time was 59±11 min, and the mean harvested length was 17±1.7 cm. No adjunctive procedures were required during vessel harvesting, and no conversions to the open technique were necessary. Harvesting complications included 2 cases of postoperative hematoma and 7 cases of superficial radial nerve paresthesia. Five postoperative angiographies were performed and all radial arteries were patent. Overall, 24/25 (96%) patients were satisfied with the procedure.

**Conclusion:** The ERAH technique was performed as safely as the traditional open technique and the harvested radial arteries were acceptable as CABG conduits. In particular, patient satisfaction with the procedure regarding the cosmetic results was excellent. (*Ann Thorac Cardiovasc Surg* 2005; 11: 391–6)

**Key words:** endoscopic radial artery harvesting, coronary artery bypass grafting

### Introduction

The radial artery has become one of the most commonly used arterial grafts next to the mammary artery.<sup>1)</sup> How-

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ever, the traditional open harvesting technique used to obtain the radial artery requires a long and unsightly incision from the wrist to the antecubital fossa. Some patients suffer hypertrophic scar healing, even in the presence of normal sternal wound healing, and/or complications of the forearm wound. In addition, some patients find the scar cosmetically unappealing.

Following the success of endoscopic saphenous vein harvesting (ESVH),<sup>2)</sup> endoscopic radial artery harvesting (ERAH) was successfully performed by some surgical groups.<sup>3)</sup> In an attempt to reduce wound complications and cosmetic problems, we initiated ERAH at our institution in February 2004 utilizing the VasoView System

(Guidant Corporation, Indianapolis, IN). Our initial experience and short-term clinical follow-up of ERAH patients are described below.

## Materials and Methods

### Patients

Between 2 February 2004 and 7 January 2005, 25 patients underwent ERAH for elective coronary artery bypass grafting (CABG) in our institution. The mean age of the patients was  $64 \pm 10$  years (range: 44-79 years) and 16% (n=4) were female. Twenty-four patients underwent primary CABG and one patient underwent re-CABG. Twenty-four patients underwent isolated CABG and one underwent CABG with a left ventricular aneurysm resection. Twenty-four radial arteries were harvested from the nondominant arm and one from the dominant arm. All patients underwent a preoperative Allen test to assess the competence of the palmar arch.

Prior to surgery, written informed consent was obtained from all patients.

### Surgical technique

#### *Preparation of the harvesting arm*

A tourniquet was placed high on the upper arm, but not pressurized, and connected to an insufflation device. The donor arm was prepped and draped, and the hand was covered with a sterilized glove.

#### *Skin incision*

A 2-3 cm longitudinal incision was made over the radial artery, just proximal to the wrist crease. An initial dissection was carried out to identify the radial artery and accompanying venae, and to create a space for insertion of a blunt tip trocar (BTT) port. After exposure of the radial artery, sodium heparin (5,000 U) was administered intravenously and the entire hand and forearm were wrapped from the distal region to the proximal region with an Esmark bandage (Medline, Mundelein, IL). The tourniquet was then inflated to 220-230 mmHg and the Esmark bandage was released.

#### *Radial artery dissection*

A 5 mm 0-degree fiberoptic endoscope (Guidant Corporation) was inserted into a VasoView conical tip dissection cannula (CDC; Guidant Corporation) and connected to a fiberoptic video system. The BTT port was inserted into the wound and its balloon was inflated to the minimum amount necessary to seal the incision (no more than

10 cc of air was required). Standard gas tubing was attached to the BTT port and CO<sub>2</sub> insufflation at 5 L/min with a pressure of 15 mmHg was utilized for tunnel expansion. The CDC was inserted through the BTT port and anterior dissection of the radial artery was continued to the antecubital fossa by slipping the CDC under the lateral intermuscular fascia and lifting the tip anteriorly to avoid placing dissection pressure on the radial artery. The dissection was carried out to no further than the recurrent radial artery or the large venous plexus that exists just proximal to the antecubital fossa. After posterior and lateral dissections were carefully performed without contacting the radial artery directly, artery branch exposure was carried out to clear the tissue and allow efficient branch cauterization and division with minimal tension.

#### *Radial artery harvesting*

The fiberoptic scope was inserted into the VasoView Uniport™ Plus (Guidant Corporation, Indianapolis, IN) using the bipolar scissors and cradle. Next, the Uniport Plus was inserted into the dissected tunnel through the BTT port and a fasciotomy of the lateral intermuscular septum was performed over the length of the forearm. Any anterior tributaries were divided by bipolar electrocautery set to 35 W. The tissue and tributaries identified laterally on each side of the radial artery pedicle were also divided by bipolar electrocautery, maintaining the spatial distance between the artery and the bipolar scissors by using the cradle to stabilize the pedicle. The cradle was then run along the radial artery and accompanying venae to confirm that all the side branches had been divided. The Uniport Plus was advanced to the end of the tunnel and a "stab" incision was made into the tunnel. A mosquito clamp was inserted into the stab incision, and the radial artery pedicle was grasped. The radial artery was then divided with the bipolar scissors with no coagulation, and the radial stump was pulled through the stab incision and ligated with sutures. The dissection of the distal radial artery pedicle was performed under direct observation with electrocautery in the same manner used for the traditional open harvesting technique. The forearm was then wrapped with an elastic bandage and the tourniquet was released. The hand was immediately assessed for blood flow by pulse oximetry.

#### *Radial artery graft preparation*

The radial artery was gently flushed with Verapamil plus nitroglycerin solution (VG solution),<sup>4)</sup> balanced at pH 7.4, and the side branches were ligated with hemoclips. The

radial artery was placed in VG solution until use as a CABG conduit. After the CABG had been performed, and the heparin was reversed, the wrist incision was closed with 3-0 Vicryl (Ethicon Inc., Somerville, NJ) and 4-0 monofilaments. The stab incision was closed with 4-0 monofilaments alone. The entire forearm was then tightly wrapped with an elastic bandage, but continued to be assessed for blood flow by pulse oximetry.

### Data collection

All clinical data for the patients were collected from our prospective database. Specific information related to the ERAH, including complications and impressions of the process, was collected using questionnaires sent to the patients or via a telephone interview. The patients were followed up in our outpatient clinic or by cardiologists. The mean clinical follow-up was  $8\pm 2.9$  months (range: 3-13 months).

### Evaluation of the harvested radial artery

The proximal segment of the radial artery was harvested with ERAH while the distal segment harvested with electrocautery similar to the traditional open technique. Therefore, both end segments of the radial artery were excised and fixed in 10% buffered formalin to compare the two harvesting techniques by histological examination. Immunohistochemical staining for CD31 expressed on the vascular endothelium as well as the presence of capillaries in the adventitia of the proximal and distal segments were examined by a pathologist. Postoperative angiography was performed in 5 patients at follow-up.

### Statistical analysis

The results are expressed as mean values  $\pm$  standard deviation. Statistical analyses were performed with Fisher's exact test. A *p* value of less than 0.05 was considered significant.

## Results

### ERAH technique

All 25 radial arteries were harvested successfully using the ERAH technique, and all conduits were found to be usable for grafting by visual inspection. No conversions were made from ERAH to the traditional open technique. No additional incisions were required to ensure vascular hemostasis. No patients required exploration of the wound for recurrent bleeding.

The mean harvest time was  $59\pm 11$  min (range: 45-97

**Table 1. Clinical results of endoscopic radial artery harvesting**

Length of distal incision (mm)	19.9 $\pm$ 4.3 (15-30)
Length of graft (cm)	17 $\pm$ 1.7 (14.2-20)
Harvest time (min)	59 $\pm$ 11 (45-97)
Number of distal coronary anastomoses (n)	3.5 $\pm$ 1.4 (2-8)
Graft flow of RA (ml/min)	54 $\pm$ 37 (14-130)

Data are the mean  $\pm$  standard deviation (range).

RA, radial artery.

min). The harvest time decreased from 97 min for the first cases to less than 50 min for the last 3 cases. The mean length of the graft was  $17\pm 1.7$  cm (range: 14.2-20 cm). The mean length of the distal incision was  $19.9\pm 4.3$  mm (range: 15-30 mm), and the mean length of the stab incision was  $5\pm 0.5$  mm (range: 4-7 mm).

Twenty-four patients underwent primary coronary revascularization and one patient underwent re-CABG. Twenty-four patients underwent isolated CABG and one underwent CABG with a left ventricular aneurysm resection. Among all the CABG procedures, 20 were performed without a cardiopulmonary bypass. The mean number of distal anastomoses per patient was  $3.5\pm 1.4$  (range: 2-8). The mean graft flow of the radial arteries was  $54\pm 37$  ml/min (range: 14-130 ml/min) (Table 1).

### Postoperative follow-up

None of the patients had any vascular compromise or ischemic complications of the hand. No wound infections of the hand occurred. Two hematomas occurred, but neither required drainage. One patient had tolerable pain in the distribution of the superficial radial nerve (SRN), but this was relieved at 3 months. Five patients had tolerable numbness in the distribution of the SRN, which showed no change in 3 patients and was relieved in 2 patients at 3 months. One patient had abnormal sensibility in the distribution of the SRN, but this had disappeared at 3 months. At follow-up, only 1 patient had a residual clinical problem due to a symptom (Table 2).

The mean patient satisfaction score was 3.4 (4: complete satisfaction; 3: satisfaction; 2: some satisfaction; 1: no satisfaction) at follow-up (Table 3).

### Histological examination

The proximal and distal segments of 11 radial arteries were examined and compared. Overall, there was intact endothelium in 2 proximal and 2 distal segments, partial endothelium in 5 proximal and 6 distal segments, and no endothelium in 4 proximal and 3 distal segments. Capil-

**Table 2. Postoperative neurologic complications of the superficial radial nerve**

	1 week	3 months	Clinical relevance at 3 months
Pain	1	0	0
Numbness	5	3	1
Abnormal sense	1	0	0
Total	7 (28%)	3 (12%)	1 (4%)

**Table 3. Patient satisfaction score of endoscopic radial artery harvesting**

Degree of satisfaction (score)	Number of patients (n=25)
Complete satisfaction (4)	12
Satisfaction (3)	12
Some satisfaction (2)	1
No satisfaction (1)	0
Mean satisfaction score	3.4

**Table 4. Histological examination**

		Proximal (n=11)	Distal (n=11)	<i>p</i> value
Endothelium	Intact	2	2	NS
	Partial	5	6	NS
	None	4	3	NS
Capillaries in the adventitia	+	10	8	NS
	-	1	3	NS

NS, not significant.

larities remained in the adventitia in 10 proximal and 8 distal segments, and were absent from the adventitia in 1 proximal and 3 distal segments. Analyses using Fisher's exact test revealed that neither the frequency of endothelium damage nor the frequency of adventitia damage differed significantly (Table 4).

### Postoperative angiography

The mean period of angiography performed postoperatively was 3.2±2.9 months (range: 1-8 months). All 5 conduits subjected to postoperative angiography revealed neither stenosis nor occlusion. The overall patency of the radial artery grafts harvested with ERAH was 100%.

### Discussion

Since the revival of radial artery grafting by Acar and colleagues in 1992,<sup>5</sup> many groups have published encouraging results<sup>6-9</sup> and the radial artery has become one of the most commonly used arterial grafts next to the mam-

mary artery. The radial artery harvesting technique used in these studies was the traditional open technique, and our institution has always used an open technique similar to that described by Reyes and colleagues.<sup>10</sup>

The ERAH technique was first described by Terada and colleagues.<sup>3</sup> Connolly and colleagues have since reported results for 300 consecutive patients subjected to ERAH utilizing the Harmonic Scalpel (Ethicon Endosurgery Inc., Cincinnati, OH).<sup>11</sup> Casselman and colleagues have described their initial experience of an ERAH kit provided by CardioVations (a division of Johnson & Johnson, Somerville, NJ) performed on 54 patients.<sup>12</sup> They also utilized the Harmonic Scalpel. Our technique differed from these previous techniques in a number of ways. First, we utilized a different system (VasoView® Endoscopic Vessel Harvesting System) that included the use of bipolar electrocautery instead of the Harmonic Scalpel. We also used a tourniquet to increase the operating field by collapsing the radial artery and associated veins and to decrease the risk of bleeding. Miles et al.



**Fig. 1.** Comparison of the cosmetic results of two patients following endoscopic radial artery harvesting (A) versus the traditional open technique (B).

and Patel et al. have also described the ERAH technique with this system.<sup>13,19)</sup>

Neurologic complications related to the lateral antebrachial cutaneous nerve (LABCN) did not occur in this series of patients. This depends on the ERAH technique being performed underneath the brachioradialis muscle. On the other hand, neurologic complications related to the SRN occurred in 7 (28%) patients. Neurologic complications in the range of 10.7-67.8% have previously been reported in patients subjected to the open technique.<sup>14-18)</sup> The reported incidence of neurologic complications with ERAH ranges from 1-27.7%.<sup>11-13,19)</sup> The occurrence of neurologic complications in this series was 28%, but the clinical relevance was limited to only 1 patient (4%) and this was comparable to the other series. Since the SRN runs laterally to the radial artery in the distal forearm, this nerve may be encountered during distal radial artery dissection, especially when operating near the distal incision. We suspected that the reason for the SRN neurologic complications was compression of this nerve by the BTT port, and therefore elongated the distal incision in the last 4 patients of this series by about 5 mm. None of these 4 patients suffered neurologic complications of the SRN.

We compared the distal and proximal segments of the radial artery by histological findings to examine the integrity of the conduit. Since the proximal segment was harvested with ERAH and the distal segment harvested by electrocautery similar to the traditional open technique, this analysis represents a direct comparison of radial ar-

teries harvested by these two techniques. The histological comparison revealed no differences in the frequency of abnormalities in the intimal and adventitial layers. Immunohistochemical staining for CD31 demonstrated a lack of residual endothelium in 4 proximal and 3 distal segments. This finding may be influenced by the means of excising and submitting the radial artery, and also by the fact that both were end segments.

The ERAH procedure certainly has a learning curve. The harvest time for the first case was 97 min, whereas the last 3 cases took less than 50 min. The upper limit of safety for ischemia has been suggested to be as long as 3 h.<sup>20)</sup> However, we consider that the safe limit of ischemia is 90 min, and we therefore recommend adequate training before attempting ERAH. It is also advisable for the training to include experience of ESVH, although a training model recently introduced by some companies replaces this at institutions where ESVH has not been performed.

One of the benefits of harvesting the radial artery using ERAH is cosmetic superiority. Overall, 24/25 (96%) of the patients were satisfied with the procedure. Since the incision is far smaller than that of the traditional open technique (Fig. 1), ERAH patients do not need to hesitate before wearing short-sleeved shirts, and the distal incision can be hidden under a wristwatch.

The ERAH technique was performed as safely as the traditional open technique and the harvested radial arteries were acceptable as CABG conduits. In particular, patient satisfaction with the procedure regarding the cos-

metic results was excellent. The long-term patency rates of conduits harvested with ERAH will need to be followed.

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