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# Less Invasive Radial Artery Harvesting: Two Years' Experience

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## ABSTRACT

**Background.** For coronary surgery we often use the radial artery (RA) instead of the saphenous vein, trying to exploit the advantages offered by this conduit. To eliminate the problems regarding alteration of upper-extremity function after RA procurement related to the standard conventional harvesting technique, we started using the less invasive harvesting technique with surprisingly good preliminary results. To compare the outcomes of open versus less invasive harvesting procedures, a prospective, nonrandomized study was developed by 2 centers.

**Methods.** From January 2001 to March 2003, there were 87 consecutive patients in the less invasive radial artery harvesting (LIRAH) group and 90 patients in the conventional radial artery harvesting (CRAH) group. Patient characteristics and demographics were similar in the groups. Data collection was made to evaluate possible benefits of the LIRAH technique in terms of fewer forearm and hand complications, better aesthetics, and improved patient satisfaction.

***Results***

Between January 11, 2001, and March 30, 2003, 177 patients underwent either primary or redo coronary artery revascularizations with procurement of the RA for use as a conduit with the less invasive harvesting technique. The mean follow-up was 2 months. Four patients died, and overall mortality was 2.26%. One hundred seventy-three patients were successfully examined during the first postoperative control, 85 in the LIRAH group and 88 patients in the CRAH group. Objective and subjective data were collected from the consultant. The overall average age was 60.5 years (range, 40-77 years). In the LIRAH group, the mean overall incision length (when 2 incisions were necessary, both incision lengths were measured) was 5.6 cm (range, 4-10 cm), and the mean vessel length was 16 cm (range, 10-19 cm). Eighteen patients (20.6%) necessitated double incision. Mean harvesting time (from incision to skin closure) was 43.3 min (range, 25-70 min). Fourteen patients (16.4%) presented some kind of complication during the study. There were no cases with acute ischemia, bleeding, or re-exploration. Seventy-five patients (88.2%) found the cosmetic result excellent. Ten patients (11.8%) found it good, and none considered it mediocre.

In the CRAH group, the mean incision length was 20 cm (range, 18-22 cm), and the mean vessel length was 18 cm (range, 17-20 cm ). Mean harvesting time (from incision to skin closure) was 30.8 min (range, 14-45 min). Thirty-four patients (38.6%) presented some kind of complication during the study. Three patients (3.5%) found the cosmetic result excellent. Forty-three (48.8%) found it good, and 42 (47.7%) considered it mediocre.

**Conclusions.** A potential of fewer neurological forearm postoperative complications, better aesthetics, and improved patient satisfaction can be achieved by the LIRAH technique.

## INTRODUCTION

Radial artery (RA) harvesting is a reality today. Presently, all groups using the RA have reported uniformly good mid-term results [Tatoulis 1999, Meharwal 2001]. Among the probable factors responsible for determining the present status of this conduit are the perioperative use of various pharmacological agents, the gentle hydrostatic dilation of the artery before its use, and its atraumatic harvest technique. The use of the RA is a significant aspect of the "all arterial conduits" approach that is currently favored, and which is associated with improved mid-term results [Tatoulis 2002]. Conventional RA harvesting creates a longitudinal scar in the forearm after the operation. Moreover, many patients frequently suffer from hand or forearm neurosensitive symptoms such as paraestesia, numbness, and weakness [Saeed 2001]. Sometimes infection and dehiscence, especially in diabetic or obese patients, can complicate the postoperative course. Most of these symptoms are inherent consequences of the inevitable tissue trauma and

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Figure 1. The Rad-LITE retractor and the pneumatic arm attached to the operating table.

edema around the superficial branch of the radial nerve and the lateral antebrachial cutaneous nerve. Equally important is the psychological trauma related to the cosmetic result of the scar, especially in younger patients and among women. Progress and innovation in techniques and materials that reduce complications go on continuously. In this context, the less invasive technique using the Rad-LITE system (Teleflex Medical, Research Triangle Park, NC, USA) was first introduced in the University Hospital Center in Caen, France [Massetti 2002]. This technique has also given very satisfactory preliminary results at the Cardiovascular Division of "L. Sacco" University Hospital in Milan. The first 2 years of bicentric experience and results with this technique are described below.

## MATERIALS AND METHODS

### *Patients*

From January 2001 through March 2003, 2 groups of patients were prospectively identified. Both groups consisted of patients undergoing coronary artery bypass grafting (CABG) for whom a segment of the RA was selected as a conduit for bypass grafts. Emergent cases were excluded from both groups. The first group consisted of 90 patients in which the RA was removed using the conventional radial artery harvesting (CRAH) technique. The second group consisted of 87 patients in which the RA was removed using the less invasive radial artery harvesting (LIRAH) technique with the Rad-LITE system. Patients were placed in each group by either specific surgeon preference or the availability of a physician assistant trained in LIRAH.The major limitation of our study is the nonrandomized controlled protocol.

### *Preoperative Evaluation*

Patient eligibility for RA harvesting was decided in consideration of standard inclusion/exclusion criteria. Both arms were evaluated by the preoperative screening procedures, including modified Allen test and echo-color doppler studies.

### *Surgical Equipment*

The Rad-LITE system includes a modified retractor, a self-retaining system with pneumatic locking designed to permit single-operator use (Figure 1), an endoscopic-like clip holder with a bend-tip (30° or 90°), a Beckman type muscle retractor, and a vessel loop or a hook. Only the light-panel integrated to the Rad-LITE system is not reusable. The self-retaining system can be attached to the surgery bed anywhere and at any time because it can be sterilized "in toto," and the positioning depends on the surgeon's preference or needs.

### *Surgical Technique*

**CRAH Technique.** All radial arteries were harvested with the CRAH technique as it was described by Reyes et al [Reyes 1995].

**LIRAH Technique with the Rad-LITE System.** The arm selected for donor of the RA is circumferentially prepared; the arm is extended and supinated, but not fixed on the

Figure 2. Skin incision.

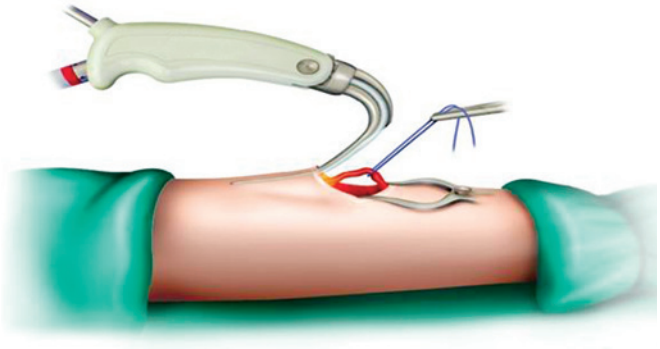

Figure 3A. The Rad-LITE retractor in place.

operative arm board, and positioned at 80° or less to the operative table. The harvesting begins with a small 3-to 5-cm skin incision, median to the forearm (Figure 2); in this zone the RA exits from underneath the cover of the brachioradialis muscle. After the skin incision, the subcutaneous tissue is divided (with electrocautery or scissors) until the RA pedicle is individualized. Then the overlying fascia is divided and the proper plane of dissection chephalad and caudal is established. A subcutaneous tunnel is created with the finger in both directions by keeping the RA pedicle bed on the "floor" and the subcutaneous and skin tissue on the "roof" of this tunnel. Care must be taken to avoid encountering collateral branches of the proximal third of the RA during the maneuver. The self-retaining system with the Rad-LITE retractor is now positioned to retract the upper tissue in the tunnel, lighting the view and giving clear visualization of the artery below (Figure 3A). The Beckman-type muscle retractor is positioned with the goal to retract the lateral walls of the tunnel made by the flexorcarpi radialis muscle medially and the brachioradialis muscle laterally. Both hands of the surgeon are now free to retract, cauterise, dissect, or clip the artery and surrounding tissues in direct vision, as in the conventional procedure (Figure 3B). Pedicle dissection begins, and with a vessel loop or hook placed, the vessel is mobilized. Light upward traction lifts the RA pedicle from its muscular bed, and the perforating branches are legated or clipped. The dissection of the entire pedicle under the skin and subcutaneous tissue is completed in both chephalad and caudal direction. An intraoperative evaluation of the ulnar flow compensation can be done by temporarily clamping the RA and noticing the pulse of the very distal part of the RA. Finally, the distal and proximal ends of the pedicle are clipped with the aid of the endoscopic-like clip holder with a bend tip (30° or 90°), and the RA is taken out. Usually the distal part can be easily clipped. If the pedicle is very long and/or visualization is not adequate, a counter-incision of 2 cm can be made at the proximal zone of the forearm. The skin incision is always closed in a standard fashion with reabsorbable sutures before proceeding with the central part of the operation. The harvested vessel and the skin incision length were measured after arm wound closure.

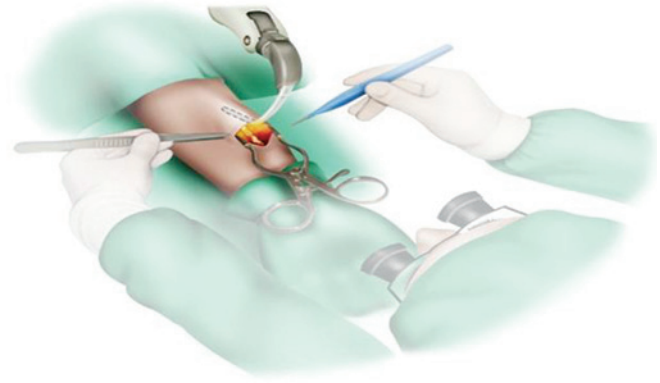

Figure 3B. Direct vision surgery.

**Postoperative Treatment.** Patients received standard postoperative care for RA grafts from paramedic personnel during hospitalization. The donor arm was monitored for ulnar pulse, temperature, color, capillary filling time, sensation, and movement in the intensive care unit every hour after arrival for the first 12 hours, then 2 times per day until discharge. Physicians were notified at any time of abnormal findings. For the length of the patient's hospital stay, no manual or automatic devices to measure blood pressure or intravenous catheters were applied to the extremity. Standard medication and a loose dressing over the forearm surgical wound were used. Until discharged, the patient was encouraged to perform hand exercises.

**Pharmacological Treatment**. A continuous intravenous infusion of diltiazem was administered through the operation ($0.25\text{-}0.50\ \mu g \times kg^{-1} \times min^{-1}$) and 180 mg/day was prescribed for a period of 6 months postoperatively.

**Follow-up.** During hospitalization, at discharge, and at 1 month, the functional status of the hand and forearm after RA harvesting was evaluated clinically in both groups, and possible complications were reported. Preoperative and operative data were also collected in a data collection form. The patient received and completed a questionnaire that reported subjective information in relation to modified hand and forearm function, strength, sensation, and appearance. This questionnaire was developed at our institution, and like other similar studies it was a nonvalidated one [Reddy 2002]. No neurovascular testing was conducted as a part of this follow-up.

## RESULTS

Between January 11, 2001, and March 30, 2003, 177 patients underwent either primary or redo coronary artery revascularizations with procurement of the RA for use as a conduit with the less invasive harvesting technique. The patient characteristics for the entire series of patients did not differ significantly between the 2 groups. The mean follow-up was 2 months. Four patients died; all were high-risk patients who developed a low cardiac output syndrome complicated with respiratory insufficiency. Overall mortality was 2.26%. One hundred seventy-three patients were successfully examined during the first postoperative control, 88 patients in the CRAH group and 85 in the LIRAH group. Objective and subjective data were collected from a consultant. The overall average age was 60.5 years (range, 40-77 years). There

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Table 1. Anastomosis with the Radial Artery*

| Graft Configuration | Number LIRAH Group | % of grafts LIRAH Group | Number CRAH Group | % of Grafts CRAH Group |
|---|---|---|---|---|
| Ao-LAD | 1 | 1.1 | 2 | 2.2 |
| Ao-D1 | 4 | 4.5 | 4 | 4.5 |
| Ao-R1 | 4 | 4.5 | 3 | 3.3 |
| Ao-OM | 21 | 23.6 | 20 | 22.5 |
| Ao-RCA | 3 | 3.3 | 4 | 4.5 |
| Ao-PD | 3 | 3.3 | 3 | 3.3 |
| Ao-sequen. | 3 | 3.3 | 3 | 3.3 |
| LITA-D1 | 1 | 1.1 | 7 | 7.9 |
| LITA-R1 | 4 | 4.5 | 4 | 4.5 |
| LITA CFX | 1 | 1.1 | 3 | 3.3 |
| LITA-MO | 21 | 23.6 | 21 | 23.6 |
| LITA-PD | 2 | 2.3 | — | — |
| LITA-sequen. | 21 | 23.6 | 15 | 16.9 |

*LAD indicates left anterior descending; D1, first diagonal; RI, ramus intermedius; OM, obtuse marginal; CFX, circumflex artery; RCA, right coronary artery; PD, posterior descending; Ao-sequen, sequential anastomosis from the aorta to 2 target coronary vessels; LITA, left internal thoracic artery; LITA-sequen, sequential anastomosis from the LITA to 2 target coronary vessels.

were 28 patients (15.8%) who had diabetes, and 114 with preoperative myocardial infarction (64.4%). Twenty-two (12.4%) were redo operations, and 46 (25.9%) patients had left-main stenosis, as documented in their preoperative assessment. There where 10 (5.65%) right RAs harvested (none bilateral).

In the LIRAH group, the mean incision overall length (when 2 incisions were necessary, both incision lengths were measured) was 5.6 cm (range, 4-10 cm), and the mean vessel length was 16 cm (range, 10-19 cm ). Eighteen patients (20.6%) needed double incision. Mean harvesting time (from incision to skin closure) was 43.3 min (range, 25-70 min). There was a total of 89 grafts used for CABG with the RA. In 50 patients (57.5%) of this group, the graft was used in a Y configuration with the left internal thoracic artery (LITA) (Table 1). Mortality was 2.3% (2 patients). All of the patients were asymptomatic for angina during the follow-up period. Table 2 summarizes harvest-related complications. Fourteen patients (16.4%) presented some kind of complication during the study. There were no cases with acute ischemia, bleeding, or re-exploration. Two patients (2.35%) presented hematoma at discharge that was completely reabsorbed by the time of the follow-up examination. In no case was it necessary to convert to the standard technique. No wound infection cases were documented during hospitalization or at the time of consultation. Five patients (5.88%) presented paresthesia at discharge, and only 2 (2.35%) at the time of consultation. Sensibility was changed for 11 patients (12.9%). One patient presented persistent itching at all of his incision sites. There was 1 patient with subjective strength loss. None of the patients reported an operative function loss. Seventy-five patients (88.2%) found the cosmetic result excellent. Ten (11.8%) found it good, and none considered it mediocre (Figure 4).

Table 2. Postoperative Complications

| Complications | Number | % CRAH group | Number | % LIRAH group |
|---|---|---|---|---|
| Ischemia | — | — | — | — |
| Bleeding | — | — | — | — |
| Hematoma | 6 | 6.81 | 2 | 2.35 |
| Reexploration | — | — | — | — |
| Neurolgic | 27 | 30.7 | 11 | 12.9 |
| Other | — | — | 1 | 1.17 |
| All | 34 | 38.6 | 14 | 16.4 |

In the CRAH group, the mean incision length was 20 cm (range, 18-22 cm) and the mean vessel length was 18 cm (range, 17-20 cm ). Mean harvesting time (from incision to skin closure) was 30.8 min (range, 14-45 min). A total of 89 grafts were used for CABG with the RA. In 50 patients (55.5%) the graft was used in a Y configuration with the LITA (Table 1). All of the patients were asymptomatic for angina during the follow-up period. Thirty-four patients (38.6%) presented some kind of complication during the study. There were no cases with acute ischemia, bleeding, or re-exploration. Six patients (6.81%) presented hematoma at discharge that was completely reabsorbed by the follow-up examination in all but 2 patients. There was 1 case of superficial wound infection during hospitalizations that necessitated antibiotic treatment and prolonged the patient's hospital stay time. Twelve patients (13.63%) presented paresthesia at discharge and 5 (5.7%) at the time of consultation. Sensibility was changed for 26 patients (29.5%). There were 3 patients with subjective strength loss. None of the patients reported an operative function loss. Three patients (3.5%) found the cosmetic result excellent. Forty-three (48.8%) found it good, and 42 (47.7%) considered it mediocre (Figure 4).

## DISCUSSION

CABG goes through continuous progress and innovation in terms of techniques, materials, and instruments. In this context, the RA is one of the conduits that is under investigation. Patients with coronary artery disease can benefit by CABG with the radial conduit, in both short- and mid-term clinical outcome [Acar 1998, Amano 2001]. The 1- and 5-year follow-ups showed a 92% and 83% patency rate, respectively [Acar 1998]. Long-term patency of the conduit needs to be elucidated. The perioperative use of specific vasoactive agents, the hydrostatic dilation of the artery before its use, and the atraumatic harvesting technique seem to be among the factors responsible for these results. To reduce overall harvesting morbidity, alternative surgical approaches have been recently developed. Endoscopic techniques are successful [Olenchock 2001, Genovesi 2001, Glajda 2001, Terada 1998] but not widely used because of the practical difficulties, the need of particular and more expensive instruments, and the longer harvesting time. Conventional RA harvesting creates a longitudinal scar in the forearm after the operation, and many patients suffer from hand or forearm symptoms such as paresthesia, numbness, weakness, and limitation of

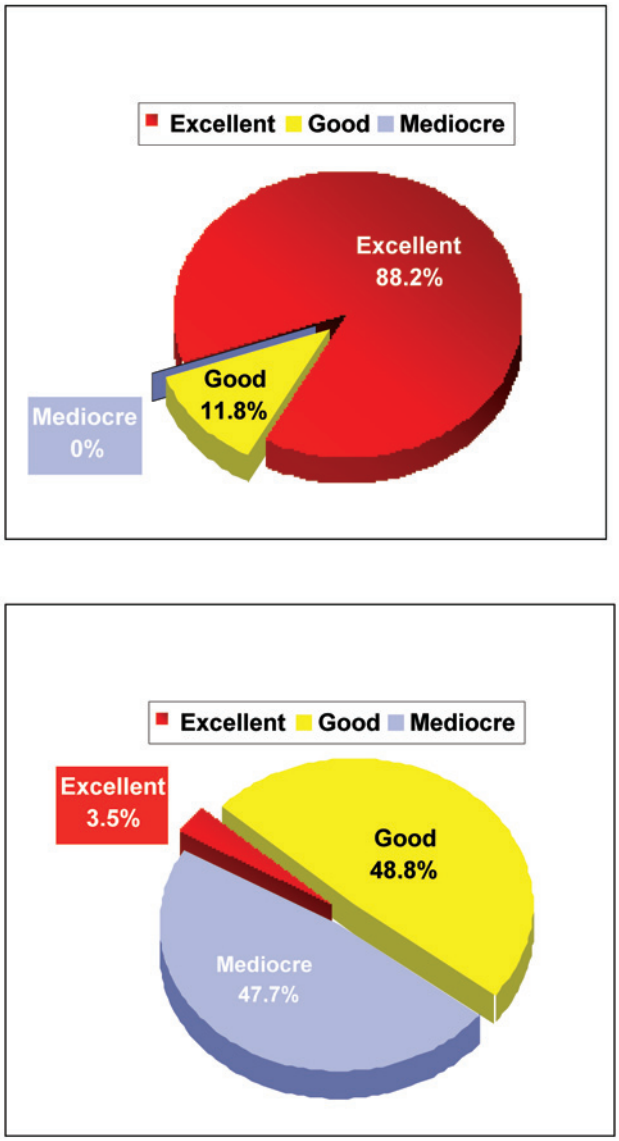


Figure 4. Cosmetic results in LIRAH group (top) and CRAH group (bottom).

hand activity [Saeed 2001, Reddy 2002]. Most of these symptoms are inherent consequences of the inevitable tissue trauma. Equally important is the psychological trauma related to the cosmetic result of the scar, which is in a particularly exposed region, especially among younger patients and women. Anyanwu and co-workers reported that of 127 patients followed, 32% had paresthesia and 51% had numbness related to the RA harvest [Anyanwu 2001]. Another study, conducted by Denton et al, proposes similar results: 30.1% had a neurological complication and 12.1% of patients had long-term neurological residual trauma [Denton 2001]. In our series, data in the CRAH group confirmed these findings. On the other hand, overall complications didn't exceed 16.4% of patients in the LIRAH group. We calculated complication/procedure ratio in both groups and saw that there were 2.3 times more complications in the CRAH group than in the LIRAH group. The less overall tissue trauma can be a possible explanation for these results. Ischemic complications are very rare—if not the exception—when correct preoperative evaluation is done and, actually, most attention is given to the neurological morbidity associated with RA harvesting. Aesthetics and consequent psychological comfort are also parameters with very important impact for a patient's quality of life. Most of the patients in the LIRAH group were very satisfied with the result. That was not the case in the CRAH group, where almost half of the patients found the cosmetic result mediocre. In the LIRAH group, the average vessel length of 16 cm was related to the operating CABG strategy, where more than 50% of the anastomosis were in a Y-graft configuration with the LITA (Table 1). When necessary, very long RA grafts were harvested. Harvesting time was higher in the LIRAH group, especially during the first procedures due to the learning curve. Graft patency angiographic control was not in the primary objectives of our study. Evidence of graft failure during the first postoperative control was not found in any patient.

## CONCLUSIONS

The aesthetic and psychological beneftits are obvious in minimally invasive surgery procedures, but it is possible that the neurological complications also can be influenced by less aggressive and more tissue-sparing surgery. These preliminary results of less invasive RA harvesting with the RadLITE system are encouraging, and although further evaluation is needed, the technique can contribute to preventing the associated morbidity.

## ACKNOWLEDGMENT

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## REFERENCES

Acar C, Ramsheyi A, Pagny J, et al. 1998. The radial artery for coronary artery bypass grafting: Clinical and angiographic results at five years. J Thorac Cardiovasc Surg 116:981-9.

Amano A, Hirose H, Takahashi A, Nagano N. 2001. Coronary artery bypass grafting using radial artery: midterm results in a Japanese Institute. Ann Thorac Surg 72:120-5.

Anyanwu AC, Saeed I, Bustami M, et al. 2001. Does routine use of the radial artery increase complexity or morbidity of coronary bypass surgery? Ann Thorac Surg 71:555-60.

Denton TA, Trenton L, Cohen M, et al. 2001. Radial artery harvesting for coronary bypass operations: neurologic complications and their potential mechanisms. J Thorac Cardiovasc Surg 121 :951-6.

Genovesi MH, Torrillo L, Fonger J, et al. 2001. Endoscopic radial artery harvest: a new approach. Heart Surg Forum 3:223-5.

Glajda Z, Peterffy A. 2001. Minimally invasive harvesting of the radial artery as a coronary bypass graft. Ann Thorac Surg 72:291-3.

Massetti M, Babatasi G, Bruno PG, et al. 2002. Less invasive radial artery approach. Heart Surg Forum 5 (Suppl 4):S392-7.

Meharwal ZS, Trehan N. 2001. Functional status of the hand after radial artery harvesting: results in 3,977 cases. Ann Thorac Surg 72:1557-61.

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Olenchock Jr SA, Reed JF, Murphy SA, et al. Endoscopic radial artery harvest as conduit for cardiac revascularization. Presented at the Fourth Annual Scientific Meeting of the International Society for Minimally Invasive Cardiac Surgery, June 27-30, 2001, Munich, Germany.

Reddy VS, Parikh SM, Drinkwater D, et al. 2002. Morbidity after procurement of radial arteries in diabetic patients and the elderly undergoing coronary revascularization. Ann Thorac Surg 73:803-8.

Reyes AT, Frame R, Brodman RF. 1995. Technique for harvesting the radial artery as a coronary artery bypass graft. Ann Thorac Surg 59:118-26.

Saeed I, Anyanwu AC, Yacoub MH, et al. 2001. Subjective patient outcomes following coronary artery bypass using the radial artery: results of a cross-sectional survey of harvest site complications and quality of life. European J of Cardio-thorac Surg 20:1142–6.

Tatoulis J, Buxton BF, Fuller JA, Royse AG. 1999. Total arterial coronary revascularization: techniques and results in 3,220 patients. Ann Thorac Surg 68:2093-9.

Tatoulis J, Royse AG, Buxton BF, et al. 2002. The radial artery in coronary surgery: a 5-year experience—clinical and angiographic results. Ann Thorac Surg 73:143-8.

Terada Y, Uchida A, Fukuda I, et al. 1998. Endoscopic harvesting of the radial artery as a coronary artery bypass graft. Ann Thorac Surg 66(6):2123-4