A Safe and Cost-Effective Approach to Minimally Invasive Radial Artery Harvesting

Kimberly Roskoph, PA-C, Forozan Navid, MD, Molly Jubeck, MPA-C, Richelle DiVito, PA-C, Venkat R. Machiraju, MD, Pablo Hong-Barco, MD, Claudio A. B. Lima, MD, and Robert D. Bennett, MD

Department of Surgery, UPMC Shadyside, Pittsburgh, Pennsylvania

Purpose. We describe a minimally invasive, cost effective, and safe method of radial artery harvesting.

Description. After obtaining informed consent and completing a preoperative evaluation, 169 radial arteries were harvested. Harvesting was accomplished through a 3-cm proximal mid forearm incision with exposure provided by a modified self-retaining lighted retractor.

Evaluation. A total of 169 radial arteries were successfully harvested. The average incision length was 2.9 cm, radial artery length was 15.8 cm, and harvest time was 32.7 minutes. No trauma to the artery or graft spasm was evident. No procedure required conversion to an open technique. Superficial cellulitis occurred in 2 patients (1.2%) and wound infection in 1 (0.6%). Three patients (1.8%) experienced intermittent residual dysesthesia. All of the patients were highly satisfied with the excellent aesthetic results. This approach allowed for a substantial cost savings compared with other minimally invasive techniques.

Conclusions. Direct minimally invasive radial artery harvesting is an acceptable alternative approach to radial artery harvesting. This method is safe, cost effective, easily reproducible, and aesthetically pleasing.

(Ann Thorac Surg 2005;80:700–3)

In the early 1970s, Carpentier and colleagues [1] first introduced the use of radial artery grafts for coronary artery bypass surgery. However, radial artery grafts were abandoned after documentation of poor patency [2, 3]. In 1989 a renewed interest in radial artery grafts took place after Acar and colleagues [4] reported patent conduits 15 years after implantation. Using improved surgical techniques and a variety of vasodilators, they reported a 1-year patency of 92%. Subsequent angiographic data has supported improved radial artery patency [5]. Consequently the radial has emerged as an acceptable conduit for coronary artery bypass grafting.

Traditional radial artery harvesting involves a longitudinal incision over the entire length of the volar surface of the forearm. The open technique results in a lengthy incision, greater local trauma, and may result in possible damage to the lateral brachial cutaneous nerve and superficial radial nerve.

We investigated an alternative method of radial artery harvesting to decrease the morbidity associated with the open technique. Although the endoscopic technique is efficacious, we are concerned by the costs as well as the steep learning curve for this technique. We describe a minimally invasive technique using direct visualization with a self-retained, lighted retractor.

Technology

Patients

In this series, 169 radial arteries were harvested. The average age of the patients was 62 years with 128 males (75.7%) and 41 females (24.3%). Sixty-one patients (36%) had diabetes mellitus. Patients were screened based on a suitable target vessel with greater than 80% stenosis and a negative preoperative Allen's test. Other factors taken into consideration included the patient's arm dominance, age, lifestyle, and history of renal insufficiency, Raynaud's disease, or previous trauma to the extremity, as well as physician preference.

Accepted for publication Aug 26, 2004.

Address reprint requests to Dr Roskoph, UPMC Shadyside, Department of Surgery, 5320 Centre Ave, Suite 216, Pittsburgh, PA 15232; e-mail: kimroskoph@hotmail.com.

Drs Roskoph, Jubeck, and DiVito disclose that they have a financial relationship with Teleflex Medical.

Published by Elsevier Inc

0003-4975/05/$30.00
doi:10.1016/j.athoracsur.2004.08.077

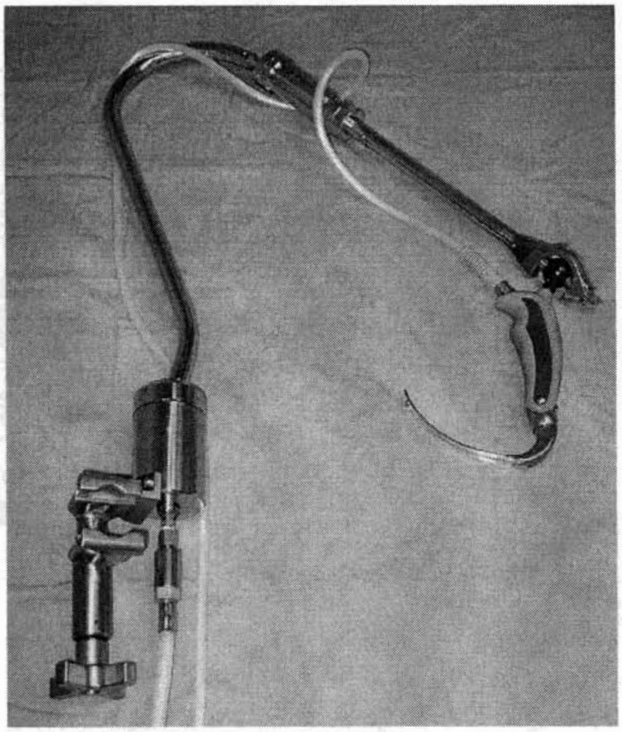

Fig 1. RadLITE Tissue Retractor System (Teleflex Medical, Research Triangle Park, NC).

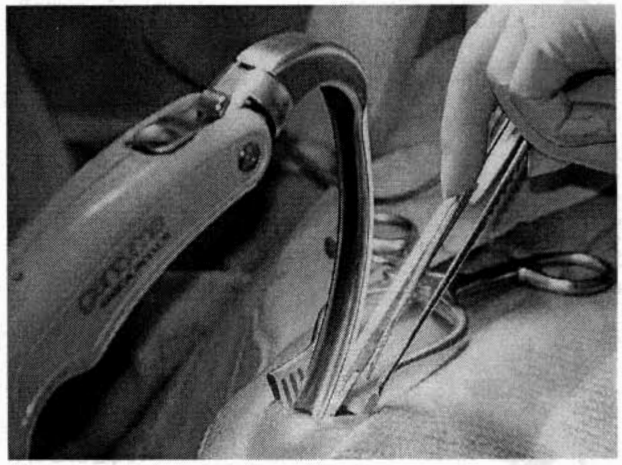

Fig 2. The hands-free self-retaining system provides the operator with direct visualization for minimally invasive harvesting of the radial artery.

Equipment

The equipment for this procedure includes a RadLITE Tissue Retractor System (Teleflex Medical, Research Triangle Park, NC), which is a modified version of the saphenous vein harvesting system (Fig 1). The system provides for direct visualization and hands-free retraction through the use of a pneumatic locking arm (Genzarm) designed for single-operator use. The arm is equipped with a number of blades that are compatible with a high transmission light panel. This panel is the only disposable component of the system.

The patient's arm is placed on an arm board, supinated, and abducted to a 90° angle from the body. The arm is firmly secured to prevent inadvertent movement during RadLITE retractor (Teleflex Medical) manipulation. The Genzarm is positioned on the operating room table below the arm board at the patient's umbilical level. Consequently this positioning allows for simultaneous harvesting of both the radial artery and the internal mammary artery. The CO_2 tank is positioned near the head of the bed and the light source is located behind the operator.

A 2.5 to 3.5 cm longitudinal incision is made on the volar surface of the forearm. This incision is positioned approximately 9 to 10 cm proximal to the wrist. We have found that the position of this incision at this level allows for maximum utilization of the retractor blade. Through this incision, the radial artery is located and its quality is assessed. A tunnel is created for the RadLITE blade (Teleflex Medical) by separating the anterior fascia between the brachioradialis and flexor carpi radialis muscle bundles. Under direct visualization, proximal dissection of the artery pedicle begins by positioning the blade into the space created above the artery (Fig 2) A blunt 8″ Beckman Weitlaner (Pilling [Teleflex Medical]) retracts the muscles providing greater visualization. During dissection, care is taken to identify and avoid the superficial radial nerve and lateral brachial cutaneous nerve. We believe that minimal manipulation decreases endothelial damage and the potential for vasospasm. Side branches are divided by the use of Starion Thermal Ligating Shears (Starion Instruments, Saratoga, CA), clips or ultrasonic coagulating devices. Proximal dissection of the artery is discontinued distal to the venous plexus and the radial recurrent artery. The artery is ligated with a right angle medium Hem-o-lok (Weck [Teleflex Medical]). The artery is transected and retrograde bleeding is assessed. The retractor is then repositioned distally. A similar tunnel is created, and the artery pedicle is dissected. The artery is ligated proximal to the superficial palmar artery. Once the artery has been removed, the retractor is placed into the tunnel in order to assess hemostasis. A drain is not routinely used, but may be placed if necessary. The incision is then closed in two layers of absorbable suture, and a sterile dressing is placed over the incision. A gauze wrap is applied and remains in place for 12 hours postoperatively. The arm can then be tucked at the patient's side for the remainder of the operation.

The artery is cannulated and prepared, which often involves complete skeletonization of the graft. A papaverine solution of 30 mg/mL is used for gentle dilatation to confirm side branch hemostasis, and the conduit is stored in a papaverine solution bath.

Clinical Experience

The patients were assessed for hand ischemia, bleeding, wound complications, thenar dysesthesia, forearm

Ann Thorac Surg
2005;80:700–3

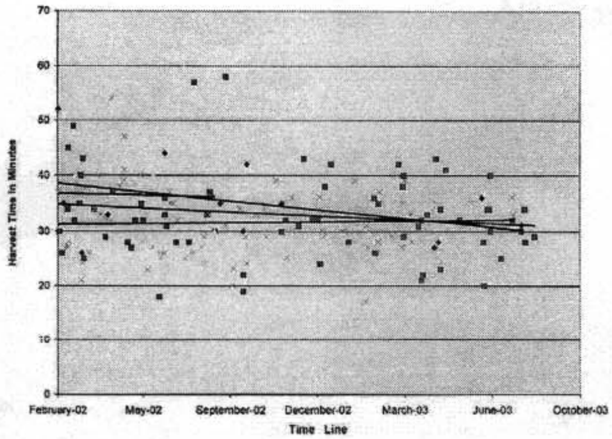

Fig 3. Flat learning curve. ◆ *= PA1;* ■ *= PA2;* ▲ *= PA3;* ✕ *= PA4;* ___ *= learning curve.*

numbness, motor dysfunction, and infection. These assessments were recorded during hospitalization at the 4- to 6-week follow-up and by subsequent telephone interviews at 3-month, 6-month, and 1-year periods.

All of the arteries harvested were of satisfactory quality and able to be used for grafting. No procedures were aborted or converted to an open technique. Of the 169 radial arteries harvested from 167 patients, 2 were bilateral, 155 were from the left arm, and 14 were from the right arm. The average conduit length was 15.8 cm. The average incision length was 2.9 cm. The average harvest time was 32.7 minutes, with a consistently flat learning curve (Fig 3). A variety of vessels were able to be grafted (Table 1). A total of 140 (83%) were aortocoronary bypasses, the other 29 (17%) included a variety of Y-grafting techniques.

No evidence of graft spasm occurred in the immediate postoperative period. A variety of drug regimes were used according to patient and physician preference. Most commonly used regimes were intraoperative diltiazem or nitroglycerin. Most patients were treated with oral Diltiazem after the first 24 hours. This regime was discontinued after 3 months.

Intraoperatively, one skin tear (0.6%) occurred and was easily repaired within the subcuticular closure. A second small incision was required to achieve hemostasis in 9 patients (5.3%). No patients required re-exploration for bleeding. No patients with hand ischemia or motor dysfunction were identified. Postoperatively, 2 patients (1.2%) with superficial cellulitis and 1 wound infection (0.6%) occurred, all of which were successfully treated with antibiotic therapy. During the immediate postoperative period, 3 patients (1.8%) died secondary to noncardiac related complications. Of the surviving 166 patients, 32 (19.2%) reported thenar dysesthesia during follow-up. In subsequent follow-up, 29 of 32 patients (91%) reported resolution. Only 3 of 166 patients (1.8%) experienced intermittent residual dysesthesia (Table 2). Due to the transient nature of the dysesthesia, which resolved in 3 to 6 months, we most likely conclude that this finding was due to neurapraxia during manipulation of the superficial radial nerve. No sensory deficits in the distribution of the lateral brachial cutaneous nerve were identified. All patients expressed high satisfaction with the final cosmetic result (Fig 4).

Table 1. Vessels Grafted

70 Obtuse marginal
27 Diagonal
26 Right coronary
23 Posterior descending
8 Circumflex
7 Posterior lateral branch
5 Ramus intermedius
3 Left anterior descending

Table 2. Postoperative Complications

Postoperative Complication	Number	Percent
Thenar dysesthesia, resolved	29	17.4%
Thenar dysesthesia, intermittent residual	3	1.8%
Superficial cellulitis	2	1.2%
Wound infection	1	0.6%
Re-exploration	0	0
Ischemic hand	0	0

Comment

The use of the radial artery for coronary bypass grafting has re-emerged as an acceptable conduit. We have used techniques from saphenous vein harvesting and adapted them for the radial artery harvesting. This method has proven to be safe, easily reproducible, and a cost effective alternative to other techniques. This technique provides the operator with direct vision and a self-retaining system so that the artery can be harvested in an efficient

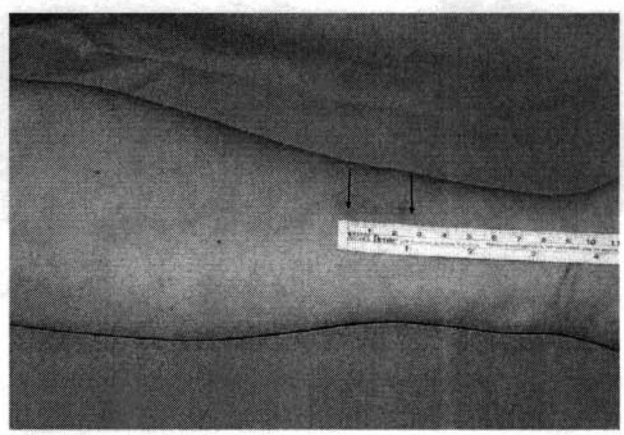

Fig 4. This technique produces a superior cosmetic result. Arrows *represent incision length.*

Table 3. Economic Benefit of Direct Vision Minimally Invasive Harvesting

No. of Procedures	Cost per Procedure RadLITE[a] ~$325	Cost per Procedure Endoscopic ~$730	Cost per Procedure Endoscopic ~$925	Average Cost Savings with RadLITE[a] Use
50	$16,250	$36,500	$46,250	$25,125
100	$32,500	$73,000	$92,500	$50,250
150	$48,750	$109,500	$138,750	$75,375
250	$81,250	$182,500	$231,250	$125,625
500	$162,500	$365,000	$462,500	$251,250
1,000	$325,000	$730,000	$925,000	$502,500

[a] RadLITE Tissue Retractor System (Teleflex Medical, Research Triangle Park, NC).

manner with minimal trauma. In addition, this technique allows for a relatively flat learning curve.

This method proved to be safe, as in our series, there were no cases of hand ischemia identified. This method also avoids the use of a tourniquet, the potential for CO_2 embolism or pneumothorax, and the discomfort associated with a wrist incision.

The learning curve, as documented by our series, remains relatively flat. We believe this technique can easily be taught to physician assistants or surgeons harvesting the radial artery.

Unlike other methods for minimally invasive radial artery harvesting, no costly video equipment is required, and the light panel is the only disposable portion of this system. All other components are reusable, allowing for a cost effective approach to radial artery harvesting. The list price for this system is $325, which compares favorably with other minimally invasive systems with list prices that can range from $730 to $925. The latter prices do not reflect or include the cost of the video equipment necessary for these other systems. The compounded economic benefits of this system can be significant (Table 3). In addition, we have been able to further increase our savings upwards of $700 per procedure with volume pricing when compared with other radial artery harvesting systems available in this country.

In our experience, no procedures were aborted or converted. All of the radial arteries were of satisfactory quality. The ability of this technique to harvest usable conduit was confirmed by the work of Massetti and colleagues [6] showing minimal signs of trauma or anatomic lesions attributed to this technique.

We also believe that this technique allows for minimal tissue damage and decreases the risk of neurologic injury. When compared with other methods of radial artery harvesting, we believe our technique shows very low complication rates. Saeed and colleagues [7] reported a 67.7% neurologic complication rate. Shapira and colleagues [8] reported a 56% dysesthesia rate. Denton and colleagues [9] reported an overall complication rate of 30.1%. Thus, we believe that our technique compares very favorably with other published reports.

In summary, this technique allows for cost effective, minimally invasive harvesting of the radial artery conduit with relative speed, low complication rate, and high patient satisfaction.

Disclosures and Freedom of Investigation

Materials for this series were purchased from Teleflex Medical. No industry grants were used to conduct this investigation. In addition, the authors had full control of the design of the study, methods used, outcome measurements, analysis of data, and production of the written report.

References

1. Carpentier A, Guermonprez JL, Deloche A, Frechette C, Dubost C. The aorta-to-coronary radial bypass graft: a technique avoiding pathological changes in grafts. Ann Thor Surg 1973;16:111–21.
2. Curtis JJ, Stoney WS, Alford WC, Burrus GR, Thomas CS. Intimal hyperplasia: a cause of radial artery aortocoronary bypass graft failure. Ann Thorac Surg 1975;20:628–35.
3. Fisk RL, Brooks CH, Callaghan JC, Dvorkin J. Experience with the radial artery graft for coronary bypass. Ann Thorac Surg 1976;21:513–8.
4. Acar C, Jebara VA, Portoghese M, et al. Revival of the radial artery for coronary artery bypass grafting. Ann Thorac Surg 1992;54:652–60.
5. Acar C, Ramsheyi A, Pagny JY, et al. The radial artery for coronary artery bypass grafting: clinical and angiographic results at 5 years. J Thorac Cardiovasc Surg 1998;116: 981–9.
6. Massetti M, Babatasi G, Bruno P, et al. Less invasive radial artery harvest. Heart Surg Forum 2002;5(Suppl 4):S392–7.
7. Saeed I, Anyanwu AC, Yacoub MH, Amrani M. 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. Eur J Cardiothorac Surg 2001;20(6):1142–6.
8. Shapira OM, Alkon JD, Aldea GS, Madera F, Lazar HL, Shemin RJ. Clinical outcomes in patients undergoing coronary artery bypass grafting with preferred use of the radial artery. J Card Surg 1997;12:381–8.
9. Denton Ta, Trento L, Cohen M, et al. Radial artery harvesting for coronary bypass operations: neurologic complications and their potential mechanisms. J Thorac Cardiovasc Surg 2001; 121:951–6.

Disclaimer