# Technical Aspects of Harvesting the Radial Artery with the Harmonic Scalpel

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C. Locker, Y. Ben-Gal, Y. Paz, O. Lev-Ran, N. Nesher, G. Uretzky, R. Mohr, I. Shapira

Department of Cardiothoracic Surgery, Tel Aviv Sourasky Medical Center, Tel Aviv, Israel



**Background:** Harvesting the radial artery (RA) with ultrasonic dissection with the Harmonic Scalpel reduces spasm induced by surgical handling. Topical exposure to phentolamine methanesulphonate (Regitine) exerts an additional effect of vasodilatation.

**Methods:** Between January and December 2002, the RA was harvested as a pediculated vessel with the Harmonic Scalpel in 145 consecutive patients undergoing myocardial revascularization. A fasciotomy of the pedicle was performed after harvesting. A composite graft with the reverse free RA on the in situ left internal thoracic artery (ITA) was prepared before the construction of distal coronary anastomoses. The RA was then placed in a syringe filled with Regitine (0.07  $\mu$ g/mL) for 10 minutes.

**Results:** The mean number of grafts/patient was 3.0. The mean number of RA anastomoses was 2.0/patient. Left ITA free flow was  $105 \pm 34$  mL/min. Regitine increased the RA free flow from  $60 \pm 35$  mL/min to  $82 \pm 30$  mL/min (P < .05). Fourteen patients underwent postoperative coronary angiography. All RA anastomoses were patent.

**Conclusion:** The compound effect of RA harvesting with the Harmonic Scalpel and topical treatment with the  $\alpha$ -blocking agent Regitine increases the RA free flow and significantly decreases intraoperative spasticity.

### INTRODUCTION

The radial artery (RA) was introduced into clinical practice by Carpentier et al in the early 1970s [Carpentier 1973]. However, its use was soon abandoned because of high occlusion rates compared with saphenous vein grafts and internal thoracic artery (ITA) grafts. Carpentier suggested that the high occlusion rates were related to spasm that developed in the RA during harvesting [Carpentier 1975]. The RA is a

Address correspondence and reprint requests to: Professor Rephael Mohr, Department of Cardiothoracic Surgery, Tel Aviv Sourasky Medical Center, 6 Weizmann St, Tel Aviv 64239, Israel; 972-3-697-3322; fax: 972-3-697-4439 (e-mail: shapiraiz@tasmc.health.gov.il). muscular artery, and its media is much thicker than that of other conduits used for myocardial revascularization [van Son 1990, He 1995]. The vasoconstriction in the RA in response to harvesting is more intense and more difficult to reverse [Chardigny 1993].

Acar et al suggested that the harvesting technique itself, as well as the graft preparation that was employed 20 years ago, could have been responsible for spasms [Acar 1992]. The RA was occasionally dissected alone and separated from its satellite veins; it was then dilated with metallic probes of increasing size introduced into the vessel lumen. Acar et al proposed dissecting the RA en bloc, together with its pedicle, to reduce the trauma associated with RA harvesting. Dilatation of the graft could then be undertaken, with blood and papaverine used to release any segmental spasms [Acar 1992].

Despite significant experience in what were considered meticulous, atraumatic methods, significant spasm was found to occur in many RAs, with loss of pulsation occurring during harvesting and no distal flow after completion of the proximal anastomosis (before the distal anastomosis). Experience with ultrasonic dissection (Harmonic Scalpel [HS], Ethicon, Cincinnati, OH, USA) of RA pedicles and avoiding hemostatic clips led to reduced spasm in the conduit [Posacioglu 1998].

According to He and Yang, RA contraction (or spasm) is almost inevitably encountered during surgical dissection and warrants the use of vasodilators during and after harvesting [He 1997, He 1998]. In their study, He and Yang showed that the RA has a dominant  $\alpha$ -adrenoreceptor function. Catecholamines in the circulation will mainly contract the human RA by activating  $\alpha_1$ -adrenoreceptors and, to a lesser extent, by activating the postjunctional  $\alpha_2$ -adrenoreceptor. They suggested that this activated contraction might be effectively antagonized by an  $\alpha_1$ - and  $\alpha_2$ -adrenoreceptor antagonist.

In a recently published study, we demonstrated that topical treatment of skeletonized RAs with the  $\alpha$ -blocker phentolamine methanesulphonate (Regitine) increases RA free flow and is an effective intraoperative means of decreasing RA spasticity [Locker 2002].

This study evaluates the compound effect of RA harvesting with the HS and topical treatment with Regitine on the spasticity of RAs connected end-to-side to left ITAs in situ.

## MATERIALS AND METHODS

Between January and December 2002, 145 consecutive patients underwent complete arterial myocardial revascular-

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ization with the left ITA and the RA. The Allen test with pulse oxymetry was used to assess the adequacy of the blood supply to the nondominant hand from the ulnar artery [Acar 1992]. All ITAs were harvested as skeletonized vessels; all RAs were harvested as pedicles, together with the veins, fascia, and accompanying tissue. The RA pedicle was harvested with the HS [Posacioglu 1998] at moderate intensity. RA branches that bled after transection were controlled with medium-sized metal clips. In all patients studied, the left (nondominant) RA was harvested at the same time as the left ITA. The distal ends of both arteries were double-clipped and divided after heparin (300 U/kg) administration. The distal RA was divided 2 cm above the wrist joint to preserve collateral circulation. Closing the distal end of the artery enabled hydraulic distention of the artery by pulsation of the arterial pressure wave against the walls of the blocked artery. The skeletonized ITA blocked in situ was put in a small syringe filled with a 1:30 papaverine-saline solution ("Jacuzzi"), suitable for relaxing any spasm produced during ITA dissection without the risk of endothelial damage associated with intraluminal mechanical dilatation or papaverine injection [Locker 2002]. Similarly, the skeletonized RA blocked in situ was put into a Jacuzzi filled with 10 mg Regitine in 150 mL saline solution [Locker 2002] after fasciotomy of the thin fascia covering the anterior surface of the pedicle.

A composite T graft with the free RA on the left ITA in situ was prepared before construction of the first coronary anastomoses in off-pump patients and before connection to cardiopulmonary bypass in patients operated on with extracorporeal circulation. To expose the proximal unexposed RA to Regitine, we connected the RA to the left ITA in a reverse manner by anastomosing the dilated distal (palmar) end of the RA end-to-side to the ITA and placing the proximal end into the Regitine Jacuzzi. This maneuver enabled even hydraulic dilatation of the RA along its entire length.

ITA free flow at zero resistance was evaluated after completion of the composite T anastomosis by allowing the artery to bleed freely for 30 seconds at a mean arterial pressure of 85 to 90 mm Hg. RA free flow was evaluated by clipping the distal ITA and allowing the RA side arm to bleed for 30 seconds at a similar blood pressure. RA free flow was measured before and after topical treatment of its proximal end with Regitine.

Sixty-eight patients underwent surgery without cardiopulmonary bypass, and 77 underwent surgery with cardiopulmonary bypass and intermittent warm blood cardioplegic arrest. The left ITA was used for grafting the anterior descending artery, and the RA was used for grafting the circumflex marginals and posterior descending arteries. Sequential anastomoses were performed with both grafts as necessary. All patients were offered the option of control postoperative angiography. However, informed consent was obtained, and angiography was performed in only 14 patients (9.6%).

#### **Statistics**

Data are expressed as the mean  $\pm$  standard deviation. The Student t test and the paired t test were used to compare flow data.

## RESULTS

The study group included 90 men and 55 women. The mean age was 69 years (range, 61-80 years). Seventy-six patients were older than 70 years, 63 had diabetes, and 12 had left ventricular dysfunction (ejection fraction <35%). There were 18 patients with peripheral vascular disease, and 13 underwent repeat operations. The mean number of grafts was 3.0 per patient (range, 2-5). The mean number of radial anastomoses was 2.0 per patient.

The average rate of free flow of the skeletonized ITA with topical application of papaverine after construction of the composite T anastomosis was  $105 \pm 34$  mL/min. This rate of free flow was significantly higher than the rate in the RA side arm of the composite T graft ( $60 \pm 35$  mL/min; P < .001).

After being immersed in the Regitine Jacuzzi for 10 to 15 minutes, the proximal segment of the RA was dilated, and the RA rate of free flow increased in all patients (mean,  $82 \pm 30$  mL/min). This increase in the rate of RA free flow was highly significant (*P* = .04, paired *t* test).

The 30-day mortality rate was 2.7%. Postoperative complications included 3 sternal infections (2%), 2 cerebrovascular accidents (1.3%), and 1 case of forearm infection (0.7%). The follow-up period ranged between 2 and 12 months. There were 2 late deaths (1.3%). The overall survival rate was 96%. All ITA and RA anastomoses were patent in the 14 patients who consented to postoperative coronary angiography (Figure).

#### DISCUSSION

Harvesting the RA with the HS as a pedicled graft is quick, atraumatic, and relatively easy to perform. The assistant surgeon can complete RA harvesting and close the arm incision while the first surgeon is harvesting the left ITA.

Our results suggest that exposing the pedicled RA harvested with the HS to the  $\alpha$ -blocker phentolamine by our technique for a very short period (8-15 minutes) is sufficient to relieve the spasm induced by surgical handling of the artery. The RA is dilated, and its length and rate of free flow after the proximal composite T anastomosis is constructed are probably sufficient for the circumflex and right coronary territories.

Flow results are similar to those obtained with the skeletonized RA [Locker 2002], and we therefore think that partial skeletonization by anterior fasciotomy of the pedicled RA is sufficient to obtain adequate exposure to the  $\alpha$ -blocking agent.

Our study confirms the results of recently published in vitro studies that showed an excellent antispastic effect of topical  $\alpha$ -antagonist treatment of the RA [He 1997, He 1998, Taggart 2000, Harrison 2001]. In a study by He and Yang [He 1998], Regitine almost completely abolished the contraction of RA ring segments induced by the  $\alpha$ -agonist norepinephrine. In another study by Dipp et al, papaverine abolished the  $\alpha$ -adrenoreceptor-mediated constriction of human RA segments immersed in an organ bath for up to 30 minutes [Dipp 2001]. In contrast, the  $\alpha$ -adrenoreceptor blocker phe-



Dilated radial artery after topical treatment with Regitine solution. Postoperative control angiogram of a patient with a Regitine-treated radial artery (free radial artery on the left internal thoracic artery [LITA] in situ). Cx indicates circumflex; LAD, left anterior descending coronary artery.

noxybenzamine consistently abolished and prevented RA spasm for at least 6 hours. These authors were unable to study this  $\alpha$ -blocking effect of phenoxybenzamine for longer periods, because 6 hours was the maximum period that vessels remained fully responsive in the organ bath. They speculated that because phenoxybenzamine binds covalently and irreversibly to  $\alpha$ -adrenoreceptors, this effect is likely to persist for at least 24 hours [Taggart 2000].

The study of Dipp et al also showed significant endothelial damage in 70% of the RA rings exposed to papaverine [Dipp 2001]. This damage was not observed in RA rings exposed to phenoxybenzamine. Similar findings were obtained in an in vitro study by Harrison et al [Harrison 2001]. Constriction of RA segments in response to norepinephrine was abolished after 20 minutes' incubation in phenoxybenazmine and remained completely inhibited for at least 18 hours. On the other hand, most of the inhibition of norepinephrine-induced constriction following 20 minutes of topical treatment with papaverine was lost after 4 hours.

The antispastic maneuvers used in our study were also very effective clinically. None of the studied patients had lapsed hypoperfusion syndrome [Manasse 1996] during the immediate postoperative course. Ninety-six percent of the patients are well and asymptomatic between 2 and 12 months postoperatively, and all RAs were patent in patients who underwent control postoperative angiography.

In conclusion, this study shows that minimizing RA trauma by ultrasonic harvesting with the HS, together with a short period of topical treatment with the  $\alpha$ -blocking agent phentolamine, increases the spontaneous free flow of free RAs connected end-to-side (composite graft) to the ITA. This antispastic method enables the safe performance of complete arterial revascularization with these two arterial conduits.

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