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Endoscopic versus Mini-invasive Radial Artery Graft Harvesting for Purposes of Aortocoronary Bypass

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Abstract: The aim of the study was to compare three different methods of radial artery harvesting with regard to postoperative complications and perioperative stress of the patient. A total of 60 patients admitted for coronary artery bypass surgery were randomized into three groups. Each patient underwent extraction of radial artery, all performed by a single surgeon. The radial artery was harvested by one of the following three techniques: classical technique (20 patients), mini-invasive technique (20), and endoscopic technique (20). The time required for the graft harvest was greater in the group where the endoscopic technique was used (52.6 ± 11.3 min) than with the mini-invasive (41.5 ± 7.3 min) or the classical (27.8 ± 4.6 min) technique. Postoperative blood loss into drains was higher where the classical technique was used (35.5 ± 9.4 ml) as compared to the mini-invasive (20 ± 5 ml) or the endoscopic (10 ± 7.3 ml) technique. There was no significant difference among the groups in the rate of local neurological complications, contusion of wound edge, edema of the extremity, or wound infection rate. We observed no case of ischemia of the extremity, and a single case of postoperative

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myocardial ischemia in the group where the classical technique was used. From a clinical point of view, the mini-invasive and the endoscopic approach are comparable, but the latter is more expensive. Both mini-invasive and endoscopic techniques prolong the operation, reduce perioperative blood loss, and require additional training time.

Introduction

The long-term outcome of patients after surgical coronary revascularization is determined in particular by patency of implanted grafts. It has been confirmed by several studies that the use of both internal mammary arteries leads to a decreased need for re-interventions and improved survival rates of the patients (Taggart et al., 2001; Rohn et al., 2005).

The radial artery (RA) as a graft was introduced and also abandoned by Carpentier et al. in 1973 and later reintroduced by Acar et al. in 1992. Nowadays, it is used for myocardial revascularization especially in the form of composite graft together with the left internal mammary artery (LIMA). This combination avoids negative consequences of proximal anastomosis of RA to the aorta. Uncomplicated graft harvesting, very good mid-term and long-term graft patency according to clinical and angiographic studies (Tatoulis et al., 1999, 2009) showed superiority of RA grafts as compared to venous grafts (Possati et al., 2003). A recent randomized study by Collins et al. (2008) reports 98.3% patency of RA grafts at 5 years. However, some authors conclude that venous conduits and RA have similar mid-term and long-term patency, which is a finding that offers surgeons enhanced flexibility in planning revascularization (Hayward et al., 2010).

The classical technique of graft harvesting is a basic method of graft preparation for myocardial revascularization. However, it is associated with neurological complications, pain, and local edema more frequently than in the endoscopic or the mini-invasive graft harvesting techniques.

The need for RA grafts together with the unaffordable price of endoscopic equipment required us to develop a mini-invasive technique of RA harvest from two incisions 2–3 cm in size with the use of standard surgical instruments and to compare these two techniques with each other.

Patients and Methods

Prospectively collected data from patients who underwent RA harvesting for the purpose of myocardial revascularization between January 2005 and December 2007 were evaluated. The RA grafts were harvested by a single surgeon. Only those patients, who were indicated for triple or multiple coronary artery bypass grafting (CABG), were included in the study.

Patients with occluded RA (positive Allen's test followed by Doppler examination) were excluded from the study along with patients with hypoplastic RA, chronic dissection of RA after angiography, stenotic subclavian artery, stenotic ulnar artery, and patients on chronic dialysis, or those with other circulatory abnormalities in the palmar arch. All patients underwent X-ray examination of the donor forearm and the radiographs were evaluated for mediocalcinosis, which is another exclusion criterion. Allen's test with capillary return within 10 seconds was considered negative. Both forearm arteries were ultrasonographically assessed (linear probe with adjustable frequency 3–11 MHz, Toshiba Power Vision 6000) and patients with significant atherosclerotic changes in RA (thickening of intima and media >0.5 mm), stenosis of RA >40%, and hypoplasia of RA <2 mm were excluded from the study as well.

Altogether, 60 patients were enrolled in the study. Each patient was randomly assigned to one of the three groups corresponding with the three different harvesting techniques so that finally each group contained 20 patients. All techniques were used throughout the duration of the study. The study was approved by the Ethics Committee and conformed to the Declaration of Helsinki. An informed consent was obtained from all subjects.

Surgical techniques

Mini-invasive technique RA harvest was performed with a harmonic scalpel (The UltraCision Harmonic Scalpel 5 mm Instruments, Johnson and Johnson Gateway, USA), bipolar scissors, and a retractor (Figure 1). Preparation of RA in both the endoscopic and the mini-invasive technique began with a 3 cm incision approximately 1 cm proximally from the styloid process. In the mini-invasive technique, the operating field was exposed by a slightly opened retractor positioned into the channel above the artery. This way, the tissue above RA could be safely prepared and ultimately, the whole artery could be safely mobilized almost up to the elbow, like in the classical technique. Then, a small 1–2 cm incision was created to securely ligate the central end of RA following an administration of heparin 2 mg/kg into it. Immediately after harvesting, Redon's drain was inserted

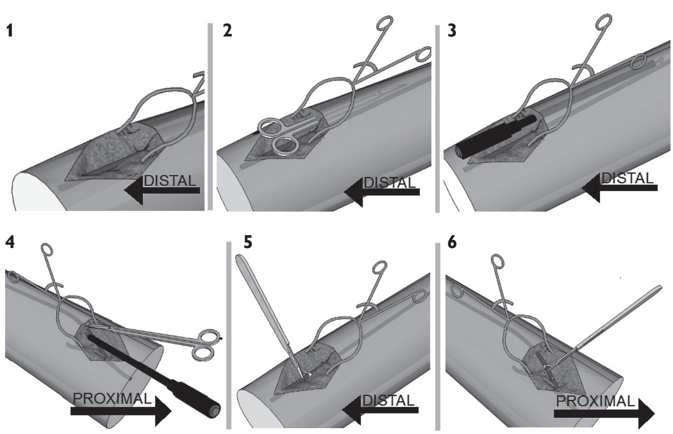

Figure 1 – Radial artery (RA) graft harvesting, mini-invasive technique – basic steps: (1) distal incision with opened retractor; (2) tissue above RA is dissected with bipolar scissors; (3) RA is mobilized using harmonic scalpel; (4) RA is dissected in the proximal incision; (5) distal and (6) proximal end of RA is clamped and disconnected.

into the channel and the two small incisions were sutured. Finally, the incisions and the channel were dressed with sterile gauze in order to achieve a better compression, better tissue contact under the skin bridge, and to prevent bleeding.

Endoscopic technique Endoscopic harvest was performed using The ClearGlide Endoscopic Vessel Harvesting system, Datascope, USA. It consists of an endoscope with oblique optics (5 mm) attached to a camera, a small ultra-retractor, a vessel dissector, endoscopic scissors, and a harmonic scalpel (The UltraCision Harmonic Scalpel 5 mm Instruments, Johnson and Johnson Gateway, USA).

The procedure began with a 3 cm incision approximately 1 cm proximally from the styloid process with subsequent preparation of the artery, which was then stepwise mobilized with dull dissection using the dissecting edge attached to the distal end of the endoscope. In order to minimize traumatization of the pedicle, the dissector always pointed away from it. The harvest was performed under video control with active CO_2 insufflation (8–10 l/min) into the extraction channel. Various instruments can be introduced into the working channel of the endoscope so fasciotomy can be carried out with the bipolar scissors or with the harmonic scalpel. The graft harvesting proceeded from the wrist up to the cubital fossa laterally from the accompanying veins with the use of harmonic scalpel. In order to avoid risk of heat damage to the graft, no electrocoagulation was used. After the RA pedicle was mobilized, a small 1–2 cm skin incision was made slightly distally from the cubital fossa in order to disconnect the artery and ligate its proximal end. Finally, Redon's drain was placed into the extraction channel and the wound was sutured with an absorbable filament. The incisions and the channel were dressed with sterile gauze and elastic bandage providing mild compression.

Classical technique The classical technique began with an incision in the forearm approximately 1 cm proximally from the styloid process which was then extended up to the cubital fossa. The incision proceeded slightly medially to the RA so as to avoid injury to terminal branches of the radial nerve. The RA was mobilized together with adjacent veins by use of the harmonic scalpel and contactless technique. Branches of RA were sealed with the harmonic scalpel maintaining a safe distance from the artery. Larger branches were clamped with clips. Finally, the wound was sutured in anatomic layers with an absorbable filament 3/0 and dressed with sterile gauze and elastic bandage providing mild compression.

Graft processing

As soon as the RA had been harvested, its distal part was clamped and dilated by intraluminally instilled solution. This consisted of 2 ml of solution of heparin (5,000 IU/1 ml), papaverine (60 mg/2 ml), nitroglycerin (5 mg/5 ml), and solution saline (5 ml), diluted in 20 ml of blood and 200 ml of solution saline. Side branches were treated with harmonic scalpel and large branches were clamped.

The graft was then placed into the solution. Finally, the RA graft was implanted on cardiopulmonary bypass ("on pump") and restitution of blood circulation was accomplished no later than 30 minutes from harvesting.

All grafts were harvested as a pedicle together with adjacent veins without external damage or intimal dissection. The incisions were closed immediately after harvesting i.e. under full heparinization. The graft harvest was carried out simultaneously with thoracotomy and a harvest of the internal mammary artery. The pedicled RA was used as a composite Y or T-graft together with the LIMA, usually for a revascularization of the lateral wall of the left ventricle. The RA graft was always used to supply an artery with stenosis over 70%. All procedures were performed on a non-dominant arm (100% of patients were right handed).

Criteria for evaluating complications

Complications related to RA graft harvesting were monitored throughout the hospital stay and in the subsequent follow-ups in the first postoperative month. Ischemia of upper extremity, wound dehiscence, fistulas, wound secretion, skin necrosis, contusion of wound edges, hematoma or seroma formation, wound infection, and finally graft damage during its harvest were surveilled. Pain was evaluated as follows: no pain, no need for analgesics, no limitation in rehabilitation – or – pain limiting rehabilitation or pain requiring administration of analgesics. Neurological examination was focused on impairment of sensitivity and mobility (evaluated by The Precise Neurological Exam, S. Russell and M. Triola, http://edinfo.med.nyu.edu/courseware/neurosurgery/). Sensitivity was evaluated in area nervina of the lateral cutaneous nerve of the forearm or superficial branch of the radial nerve and pathology was classified as hypesthesia, anesthesia, or dysesthesia. The evaluation of accompanying edema was based on a comparison of circumferences measured bilaterally in the wrist and in the cubital fossa. A difference above 2 cm between the extremities was evaluated as positive. Patients, who had to be converted to the classical technique (due to decreased visibility in the operating field) were not considered for the study.

Statistical methods

In all 3 groups, baseline entry data were compared. Categorical data were tested with the chi-square test. Where the number of observations was <5, the Fisher's exact test was used instead. Continuous data were tested with ANOVA and subsequent pairwise comparisons with the *t*-test. Differences with a p-value below 0.05 were considered significant.

Results

In an analysis of prospectively collected data of 60 patients carried out between January 2005 and December 2007, the aforementioned factors were monitored in order to compare the three techniques of RA graft harvesting.

The patients were between 37 and 71 years old (average 55.7 ± 7.2 years) and 92% of them were males. Group characteristics are shown in Table 1.

The time needed for graft harvesting with the classical technique (27.8 ± 4.6 min) was significantly shorter than with the mini-invasive (41.5 ± 7.3 min) or the endoscopic technique (52.6 ± 11.3 min, all differences $p<0.01$). This confirms that mini-invasive and endoscopic methods of graft harvesting prolong the operation.

An inflammatory complication in the wound was observed in one patient who underwent the classical harvest of RA (n.s.). The infection manifested on the

Table 1 – Group characteristics

Characteristics	Technique Classical (20 patients)	Technique Mini-invasive (20 patients)	Technique Endoscopic (20 patients)	Significance
Age (years)	53.3 ± 4.6	58.2 ± 5.9	55.7 ± 6.8	n.s.
Males	19 (95%)	18 (90%)	18 (90%)	n.s.
Females	1 (5%)	2 (10%)	2 (10%)	
Diabetes mellitus	12 (60%)	13 (65%)	11 (55%)	n.s.
DM insulin-dependent	3 (15%)	3 (15%)	4 (20%)	n.s.
DM non-insulin-dependent	9 (45%)	10 (50%)	7 (35%)	n.s.
Hypertension	13 (65%)	10 (50%)	12 (60%)	n.s.
Hypercholesterolemia	16 (80%)	12 (60%)	11 (55%)	n.s.
Chronic renal failure	2 (10%)	1 (5%)	1 (5%)	n.s.

Table 2 – Postoperative results – classical vs. mini-invasive vs. endoscopic technique

Characteristics	Technique Classical (20 patients)	Technique Mini-invasive (20 patients)	Technique Endoscopic (20 patients)	Significance
Harvest time (min)	27.8 ± 4.6*	41.5 ± 7.3*	52.6 ± 11.3*	<0.01
Wound infection	1 (5%)	0 (0%)	0 (0%)	n.s.
Contusion of wound edges and other wound complications	0 (0%)	1 (5%)	3 (15%)	n.s.
Neurological complications	4 (20%)	1 (5%)	0 (0%)	n.s.
Graft length (cm)	18.5 ± 0.7*	22.1 ± 2.4*	17.2 ± 1.5*	<0.01
Hematoma	10 (50%)**	4 (20%)	1 (5%)**	<0.01
Seroma	0	0	0	–
Edema	2 (10%)	0	0	n.s.
Ischemia of the extremity	0	0	0	–
Conversion to classical technique	–	1	1	–
Blood loss (ml)	35.5 ± 9.4*	20 ± 5*	10 ± 5*	<0.01
Hospital mortality	0	0	0	–
Perioperative myocardial ischemia	0	0	0	–
Postoperative myocardial ischemia	1 (5%)	0 (0%)	0 (0%)	n.s.
No pain	13 (65%)	18 (90%)	19 (95%)	n.s.

*all pairwise comparisons significant ($p<0.01$); **pairwise comparison significant ($p<0.01$)

5th postoperative day by formation of fistulas with purulent discharge accompanied by fever and consequent wound dehiscence. The culture was positive for *Staphylococcus aureus*. Treated with standard surgical procedures, the wound became free of infection and on the 14th postoperative day it was resutured. The hospital stay was prolonged by 10 days in comparison to patients with an uncomplicated recovery. In both the mini-invasive and the endoscopic group, one conversion to the classical technique was necessary. Further characteristics of each group are detailed in Table 2.

Discussion

For decades, RA has been harvested by the classical (open) technique from one long incision in the forearm of a non-dominant arm. Unfortunately, it became apparent that the classical technique is associated with considerable rate of wound or neurological complications not only in the immediate postoperative period but also even several months after the procedure (Budillon et al., 2003; Knobloch et al., 2005). Neurological complications usually present themselves as an impairment of sensibility (superficial branch of the radial nerve or medial cutaneous nerve of the forearm) rather than as a motoric deficit (median nerve). They occur in up to 3–4% (Denton et al., 2001; Ikizler et al., 2005). Sensory neurological complications usually manifest themselves as dysesthesias, paresthesias, or sensibility disorders, which are perceived as annoying and persistent. In patients, where the RA graft was harvested with the endoscopic technique, absolutely no neurological complications were observed, a finding consistent with a significant decrease of such complications as documented in literature (Patel et al., 2004; Rudez et al., 2007).

Wound complications in the group where the endoscopic technique was used, were limited to formation of hematoma or contused wound edges (Patel et al., 2004). Patients who underwent the mini-invasive and particularly the endoscopic harvest were less likely to develop hematoma and had significantly lower postoperative blood loss to Redon's drain. This is probably due to more extensive damage to the skin and the subcutis with subsequent mild leakage from small blood vessels in the case of the classical technique. Another positive fact is that previous studies showed comparable patency of grafts harvested with both the endoscopic and the classical technique (Patel et al., 2004; Bleiziffer et al., 2007).

Based on the above presented findings, we can recommend endoscopic technique for RA harvesting. Nonetheless, the considerable cost of single-use endoscopic and other indispensable instruments must be taken into consideration: the endoscopic set for RA harvesting costs over 600 €. Instruments used in the classical or the mini-invasive technique can be resterilized.

The mini-invasive graft harvesting technique using a harmonic scalpel and retractor appears to be a reasonable alternative to the endoscopic technique with minimal economic limitations. The graft quality is comparable to the endoscopic technique: all grafts in our study were of adequate quality, had no spasms, and were suitable for revascularization. The cosmetic effect is also favourable and the complication rate is comparable to the endoscopic technique.

Before deciding on RA harvest, a high-quality ultrasound examination is indispensable to evaluate the overall condition of the graft and to predict an impact of the harvest on the perfusion of the arm (Nicolosi et al., 2002; Knobloch et al., 2007). Currently, this examination excludes the use of RA as a graft in approximately 0.5% patients.

Compared to the classical technique, the mini-invasive and the endoscopic techniques are more difficult to master due to the limited visual contact with the graft during its harvest. The time needed to train a cardiosurgeon for the endoscopic technique is longer than for the mini-invasive technique. Proficiency in the classical technique and thorough knowledge of RA anatomy is an essential prerequisite for transition to mini-invasive or endoscopic technique. The endoscopic technique is more demanding than the mini-invasive and requires considerable experience in endoscopic harvesting of the great saphenous vein to develop the necessary skills. Those doctors, who train in the mini-invasive technique, usually advance gradually from the classical technique by decreasing the number of incisions down to just two – one in the wrist and one in the elbow.

At present, we routinely use RA for CABG in patients below 70 years of age and we prefer the classical technique as this is faster, easier, and less expensive. Nevertheless, we favour the use of the right IMA as a T-graft on LIMA where possible instead.

It is of particular interest that grafts obtained by the mini-invasive technique were significantly longer than in the other techniques. This may be due to better access to the proximal part of RA (because the bifurcation is intentionally visualized in the mini-invasive technique), which is hence disconnected closer to where the brachial artery bifurcates.

This study is based on a small cohort. From the clinical point of view, it illustrates that the mini-invasive and the endoscopic techniques of RA graft harvesting are comparable. Nevertheless, there is a substantial financial advantage in the mini-invasive technique: no need for single-use instruments, laparoscopic tower, or CO_2 insufflator.

References

Acar, C., Jebara, V. A., Portoghese, M., Beyssen, B., Pagny, J. Y., Grare, P., Chachques, J. C., Fabiani, J. N., Deloche, A., Guermonprez, J. L. (1992) Revival of the radial artery for coronary artery bypass grafting. *Ann. Thorac. Surg.* **54(4)**, 652–659.

Bleiziffer, S., Hettich, I., Eisenhauer, B., Ruzicka, D., Wottke, M., Hausleiter, J., Martinoff, S., Morgenstern, M., Lange, R. (2007) Patency rates of endoscopically harvested radial arteries one year after coronary artery bypass grafting. *J. Thorac. Cardiovasc. Surg.* **134(3)**, 649–656.

Budillon, A. M., Nicolini, F., Agostinelli, A., Beghi, C., Pavesi, G., Fragnito, C., Busi, M., Gherli, T. (2003)

Complications after radial artery harvesting for coronary artery bypass grafting: our experience. *Surgery* **133(3)**, 283–287.

Carpentier, A., Guermonprez, J. L., Deloche, A., Frechette, C., DuBost, C. (1973) The aorta-to-coronary radial artery bypass graft. A technique avoiding pathological changes in grafts. *Ann. Thorac. Surg.* **16(2)**, 111–121.

Collins, P., Webb, C. M., Chong, C. F., Moat, N. E. (2008) Radial artery versus saphenous vein patency randomized trial five-year angiographic follow-up. *Circulation* **117(22)**, 2859–2864.

Denton, T. A., Trento, L., Cohen, M., Kass, R. M., Blanche, C., Raissi, S., Cheng, W., Fontana, G. P., Trento, A. (2001) Radial artery harvesting for coronary bypass operations: neurologic complications and their potential mechanisms. *J. Thorac. Cardiovasc. Surg*. **121(5)**, 951–956.

Hayward, P. A., Gordon, I. R., Hare, D. L., Matalanis, G., Horrigan, M. L., Rosalion, A., Buxton, B. F. (2010) Comparable patencies of the radial artery and right internal thoracic artery or saphenous vein beyond 5 years: results from the Radial Artery Patency and Clinical Outcomes trial. *J. Thorac. Cardiovasc. Surg*. **139(1)**, 60–65.

Ikizler, M., Ozkan, S., Dernek, S., Ozdemir, C., Erdinc, O. O., Sevin, B., Ozdemir, G., Kural, T. (2005) Does radial artery harvesting for coronary revascularization cause neurological injury in the forearm and hand? *Eur. J. Cardiothorac. Surg*. **28(3)**, 420–424.

Knobloch, K., Lichtenberg, A., Tomaszek, S., Hagl, C., Khaladj, N., Klima, U., Haverich, A. (2005) Long-term physical activity and neurologic function after harvesting of the radial artery as T-graft or free graft in coronary revascularization. *Ann. Thorac. Surg*. **80(3)**, 918–921.

Knobloch, K., Tomaszek, S., Haverich, A., Vogt, P. M. (2007) Age deteriorates palmar microcirculation following radial artery harvesting. *Asian Cardiovasc. Thorac. Ann*. **15(6)**, 486–492.

Nicolosi, A. C., Pohl, L. L., Parsons, P., Cambria, R. A., Olinger, G. N. (2002) Increased incidence of radial artery calcification in patients with diabetes mellitus. *J. Surg. Res*. **102(1)**, 1–5.

Patel, A. N., Henry, A. C., Hunnicutt, C., Cockerham, H. A., Willey, B., Urschel, H. C. Jr. (2004) Endoscopic radial artery harvesting is better than the open technique. *Ann. Thorac. Surg*. **78(1)**, 149–153.

Possati, G., Gaudino, M., Prati, F., Alessandrini, F., Trani, C., Glieca, F., Mazzari, M. A., Luciani, N., Schiavoni, G. (2003) Long-term results of the radial artery used for myocardial revascularization. *Circulation* **108(11)**, 1350–1354.

Rohn, V., Simon, P., Devyatko, E., Vodickova, J., Pirk, J., Skalsky, I. (2005) Complete myocardial arterial revascularization vs. conventional coronary artery bypass graft surgery – interim results of the CARACCASS study. *Cor Vasa* **47(12)**, 463–469.

Rudez, I., Unic, D., Sutlic, Z., Biocina, B., Baric, D., Ivkovic, M., Pavlovic, M. (2007) Endoscopic radial artery harvesting reduces postoperative pain and neurologic complications. *Heart Surg. Forum* **10(5)**, E363–E365.

Taggart, D. P., D'Amico, R., Altman, D. G. (2001) Effect of arterial revascularisation on survival: a systematic review of studies comparing bilateral and single internal mammary arteries. *Lancet* **358(9285)**, 870–875.

Tatoulis, J., Buxton, B. F., Fuller, J. A., Royse, A. G. (1999) The radial artery as a graft for coronary revascularisation: techniques and follow-up. *Adv. Card. Surg*. **11**, 99–128.

Tatoulis, J., Buxton, B. F., Fuller, J. A., Meswani, M., Theodore, S., Powar, N., Wynne, R. (2009) Long-term patency of 1108 radial arterial-coronary angiograms over 10 years. *Ann. Thorac. Surg*. **88(1)**, 23–29.