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Radial Artery as a Coronary Artery Bypass Conduit

20-Year Results

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ABSTRACT

BACKGROUND There is a lack of evidence for the choice of the second conduit in coronary surgery. The radial artery (RA) is a possible option, but few data on very-long-term outcomes exist.

OBJECTIVES This study describes 20-year results of RA grafts used for coronary artery bypass grafting and the effects of RA removal on forearm circulation.

METHODS We report the results of the prospective 20-year follow-up of the first 100 consecutive patients who received the RA as a coronary bypass conduit at our institution.

RESULTS Follow-up was 100% complete. There were 64 deaths, 23 (35.9%) from cardiovascular causes. Kaplan-Meier 20-year survival was 31%. Of the 36 survivors, 33 (91.6%) underwent RA graft control at a mean of 19.0 ± 2.5 years after surgery. The RA was found to be patent in 24 cases (84.8% patency). In the overall population, probability of graft failure at 20 years was 19.0 ± 0.2% for the left internal thoracic artery (ITA), 25.0 ± 0.2% for the RA, and 55.0 ± 0.2% for the saphenous vein ($p = 0.002$ for RA vs. saphenous vein, 0.11 for RA vs. ITA, and $p < 0.001$ for ITA vs. saphenous vein). Target vessel stenosis >90%, but not location of distal anastomosis, significantly influenced long-term RA graft patency. No patients reported hand or forearm symptoms. The ulnar artery diameter was increased in the operated arm (2.44 ± 0.43 mm vs. 2.01 ± 0.47 mm; $p < 0.05$) and correlated with the peak systolic velocity of the second palmar digital artery (Pearson coefficient: 0.621; $p < 0.05$).

CONCLUSIONS The 20-year patency rate of RA grafts is good, and not inferior to the ITA, especially when the conduit is used to graft a vessel with >90% stenosis. RA harvesting does not lead to hand or forearm symptoms, even at a very-long-term follow-up. (J Am Coll Cardiol 2016;68:603–10) © 2016 by the American College of Cardiology Foundation.

The radial artery (RA) is the conduit most recently introduced in coronary artery bypass graft (CABG) surgery, after the great saphenous vein (SV) and the internal thoracic artery (ITA) (1). To date, there is evidence that the conduit has a post-operative patency rate higher than the SV and equivalent to the right ITA, and its use can lead to substantial clinical advantages in selected groups of patients (2). However, the RA is relatively underused. In a recent report from the Society of Thoracic Surgery Adult Cardiac Surgery Database, the RA was used in <6% of all primary isolated CABGs in the United States in the 2000 to 2009 period (3).

One of the reasons for its limited adoption is probably the fact that, up to now, only limited information exists on very-long-term results of using the RA, with most studies reporting a mean follow-up of <10 years. In addition, previous reports

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ABBREVIATIONS AND ACRONYMS

CABG = coronary artery bypass graft

ITA = internal thoracic artery

RA = radial artery

SV = saphenous vein

(including ours) have expressed concerns about possible harm to the forearm circulation after RA harvesting (4). This has possibly further limited adoption of this conduit by the surgical community.

To contribute to the diffusion of use of the RA as a coronary artery bypass conduit, we herein describe the results of the 20-year prospective follow-up of our initial cohort of 100 patients who received an RA graft for myocardial revascularization.

METHODS

The use of the RA as a coronary artery bypass conduit was started prospectively at the Catholic University of Rome in January 1993, on approval by the local Ethics Committee (5). For the first 100 consecutive patients, we adopted a very strict follow-up protocol that included the following:

- yearly clinical examination
- yearly stress test or stress myocardial scintigraphy
- 1-, 5-, and 10-year angiographic control studies
- 1-, 5-, and 10-year echo Doppler evaluation of forearm circulation

Results of the 1-, 5-, and 10-year clinical and angiographic follow-ups, and detailed descriptions of the modifications of the forearm circulation after RA removal, and of the effects of the calcium-channel blocker therapy and morphofunctional remodeling of the artery after implantation in the coronary circulation were previously published (4–10). In this report, we describe the 20-year clinical, angiographic, and echo Doppler results for this cohort of patients.

PATIENT POPULATION AND SURGICAL TECHNIQUE. Preoperative clinical details are summarized in Table 1. Details of our surgical technique have been published (5). Briefly, the same surgical team performed all operations, using cardiopulmonary bypass and cardioplegic arrest. The left ITA was usually used to graft the left anterior descending artery, whereas the RA was grafted to the second target vessel. The RA target vessel was a branch of the circumflex artery in 53 cases, a branch of the right coronary artery in 36 cases, and a diagonal in 11 cases. SV grafts usually completed the revascularization, whereas the right ITA and the gastroepiploic artery were used in a minority of cases. The RA was anastomosed to the ascending aorta in 85 patients, and to the left ITA in the remaining patients.

TABLE 1 Pre-Operative and Intraoperative Characteristics

Male/female ratio	72/28
Mean age, yrs	63.7 ± 6.6
Cardiovascular risk factors	
Diabetes	20
Smoking	56
Dyslipidemia	51
Hypertension	44
Previous myocardial infarction	60
Number of diseased vessels	2.8 ± 0.4
Mean ejection fraction	0.62 ± 0.15
Number of anastomoses per patient	2.9 ± 0.1

Values are n or mean ± SD.

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Since the beginning of our study, we adopted systematic Doppler or echo Doppler assessment of the adequacy of collateral ulnar circulation before RA removal, according to a published method (10). The RA was always harvested from the nondominant arm, and bilateral RA harvesting was never performed.

Long-term calcium-channel blocker therapy (diltiazem, 120 mg/day) was prescribed for all patients for the first post-operative year. After the results of 2 prospective randomized trials by our group (8,9), calcium-channel blocker therapy was abandoned, and is not currently part of our routine.

FOLLOW-UP. Each patient was followed up regularly at our institution 6 months after surgery and every year thereafter. At each time interval, clinical examination and echo Doppler evaluation of the forearm were performed, and the results of surface electrocardiography, stress myocardial scintigraphy, 24-h Holter monitoring, and transthoracic echocardiography were reviewed. In the case of death during the follow-up period, all medical and autopsy reports were reviewed for attribution of the cause. For out-of-hospital fatalities, the death certificate was requested and reviewed. Death was considered cardiac in origin when it was preceded by evidence of myocardial ischemia, heart failure, or arrhythmia.

Angiographic control or (in recent years) computed tomography–angiographic assessment was proposed to all patients at the early (1-year), midterm (5-year), long-term (10-year), and very-long-term (20-year) follow-up visits, and at any time when there was instrumental evidence of inducible ischemia.

Two experienced observers independently graded angiographies using a previously described 4-grade angiographic scale (perfectly patent, patent with irregularities, stringed, occluded) (6).

STATISTICAL ANALYSES. Data are expressed as mean ± SD. Statistical analysis was performed with an unpaired, 2-tailed Student *t* test for means or the chi-square test for categorical variables. Competing risks