Comparison of Radial Artery and Saphenous Vein Graft Stenosis More Than 5 Years After Coronary Artery Bypass Grafting

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Background. **Graft stenosis may be associated with future graft failure. The purpose of this investigation was to compare graft stenosis between radial artery (RA) grafts and saphenous vein grafts (SVGs) at least 5 years postoperatively using the multicenter Radial Artery Patency Study (RAPS) data.**

Methods. **Two hundred thirty-four patients underwent late invasive angiography after coronary artery bypass operations. The study population consists of 163 patients with thrombolysis in myocardial infarction (TIMI) 3 flow of both the RA graft and study SVGs. Angiograms were reviewed centrally and in a blinded fashion. Graft stenosis was recorded for the proximal anastomosis, graft body, and distal anastomosis; significant stenosis was defined as greater than or equal to 50%. Major adverse cardiac events (MACE) were reported in patients with and those without significant graft stenosis.**

Results. **There was no difference in significant graft stenosis of the patent RA grafts and SVGs (14 of 163 [8.6%] versus 19 of 163 [11.7%]) or in the proximal anastomosis (5 of 163 [3.1%] versus 5 of 163 [3.1%]), graft body (6 of 163 [3.7%] versus 13 of 163 [8.0%]), or distal anastomosis (4 of 163 [2.5%] versus 5 of 163 [3.1%]) considered separately. However, the overall burden of graft body disease was higher in SVGs ($p = 0.03$). MACE was higher in patients with significant graft stenosis than in patients without stenosis (10 of 28 [35.7%] versus 7 of 135 [5.2%]; $p < 0.0001$).**

Conclusions. **There was no significant difference in the rates of significant stenosis of patent RA grafts and SVGs more than 5 years postoperatively. However, the burden of graft body stenosis was less in RA grafts compared with SVGs, suggesting that the RA grafts will continue to outperform the SVGs late after operation.**

(Ann Thorac Surg 2016;■:■–■)

The Radial Artery Patency Study (RAPS) [1, 2] is a multicenter randomized trial comparing the longitudinal patency of radial artery (RA) grafts and saphenous vein grafts (SVGs) (Clinical Trials.gov NCT00187356). The RAPS investigators reported that the proportion of RA grafts with complete graft occlusion was lower than that with SVGs at 1 year (8.2% versus 13.6%; $p = 0.009$) as was functional graft occlusion more than 5 years postoperatively (12.0% versus 19.7%; $p = 0.03$). Similarly, a recent meta-analysis revealed that the RA grafts were superior to SVGs at midterm angiographic follow-up [3]. Graft stenosis has been well described in saphenous veins and is associated with worse long-term outcomes [4], yet the prevalence of late RA graft stenosis has not been very well described. The primary objective of this study was to characterize the prevalence, severity, and location of late graft stenosis of RA grafts and SVGs, using the late data from the RAPS trial.

Patients and Methods

Study Population

Details of the RAPS trial have been published previously [1, 2, 5, 6]. The study was approved by the research ethics committee at each participating center. All patients provided written informed consent. The Ethics Review Board

Accepted for publication Feb 16, 2016.

Presented at the Fifty-second Annual Meeting of the Society of Thoracic Surgeons, Phoenix, AZ, Jan 23–27, 2016.

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Dr Cohen discloses a financial relationship with Astra Zeneca, Medtronic Vascular, and Abbott Vascular.

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2016.02.107

Abbreviations and Acronyms

CABG = coronary artery bypass grafting
CTA = computed tomographic angiography
ECG = electrocardiogram
ITA = internal thoracic artery
LVEF = left ventricular ejection fraction
MACE = major adverse cardiac events
MI = myocardial infarction
PCI = percutaneous coronary intervention
RA = radial artery
RAPS = Radial Artery Patency Study
SVG = saphenous vein graft
TIMI = thrombolysis in myocardial infarction

from Sunnybrook Health Sciences Centre approved this RAPS substudy and waived the need for individual patient consent.

Randomization and Protocol

A within-patient randomization design was used: the RA graft was randomized to the circumflex territory and the SVG to the inferior wall, or the RA graft was randomized to the right coronary region and the SVG to the lateral wall [1, 2, 5, 6]. Each patient therefore received both study grafts. The target vessels for the RA graft and the study SVG were greater than or equal to 1.5 mm in diameter and subtended by a proximal stenosis of 70% or greater, as assessed by visual assessment of the preoperative angiogram. All grafts were harvested with an open technique. The RA graft was dilated in situ with an intraluminal injection of 4 to 5 mL of a dilute verapamil (5 mg) and papaverine (65 mg) solution (16 mL lactated Ringer's solution)[1, 2, 5, 6]. The RA graft was anastomosed directly to the ascending aorta in all cases.

Angiographic Follow-Up

Participants were approached to undergo protocol-directed angiography beyond 5 years after coronary artery bypass grafting (CABG). Any clinically indicated angiograms beyond the 3-year follow-up were also evaluated. All participating centers acquired angiograms digitally, and the image sequences were transferred to compact disks that were sent to the core study center for centralized reading. Computed tomographic angiography (CTA) was offered to the patients who declined invasive radiographic angiography; however, information regarding graft stenosis was derived only from an invasive angiogram in patients with thrombolysis in myocardial infarction (TIMI) flow grade 3 in both the RA grafts and the study SVGs. For the evaluation of graft stenosis, each study graft was divided into 3 segments (proximal anastomosis, graft body, and distal anastomosis); a percent stenosis grade based on the visual interpretation of the invasive angiogram was assigned to each portion (0 = 0%–24%, 1 = 25%–49%, 2 = 50%–74%, and 3 = 75%–99% stenosis). Each invasive angiogram was independently adjudicated in a blinded fashion by 2 invasive angiographers; a third review was conducted in the case of disagreement on the primary outcome of functional graft occlusion. For disagreements on the severity of graft stenosis, the higher grade of graft stenosis or the majority grade of graft stenosis was chosen.

Clinical Follow-Up

Patients were interviewed by telephone at 1 month, 3 months, 6 months, and yearly thereafter for a maximum of 10 years postoperatively. If the patient had been hospitalized for cardiac reasons between interviews, inpatient records were obtained. Data on death, cause of death, nonfatal myocardial infarction (MI), and repeated revascularization were obtained at each interview. All clinical events were reviewed centrally in a blinded fashion by a committee consisting of 2 cardiologists and 1 cardiac surgeon.

Statistical Analysis

Baseline characteristics were compared between patients who had TIMI 3 flow of both RA grafts and SVGs and the cohort that did not. A 2-sample t test and Wilcoxon rank-sum test were used for parametric and nonparametric continuous variables, respectively. All categorical variables (reported as frequency and percentage) were compared using the χ^2 test.

The primary end point was to determine the proportion of grafts with significant stenosis, defined as greater than or equal to 50% narrowing, of the proximal anastomosis, graft body, or distal anastomosis in the RAs and study SVGs with TIMI 3 flow. The secondary end point was to determine the presence of significant stenosis within each of the proximal regions, graft body, and distal regions of the grafts. McNemar's test was used to test for significance for both of these outcomes. We then examined graft stenosis as an ordinal variable—ie, grade 0 = 0% to 24%, grade 1 = 25% to 49%, grade 2 = 50% to 74%, grade 3 = 75% to 99% stenosis—rather than as a binomial variable. We tested the stenosis severity of the proximal anastomosis, graft body, or distal anastomosis, considered separately, of the RA graft and study SVG with TIMI 3 flow. The Bowker's test of symmetry was used to test for these comparisons [7].

The tertiary end points included determining the proportion of major adverse cardiac events (MACE) beyond 30 days postoperatively—defined as cardiac mortality, nonfatal MI, or repeated revascularization—along with determining the proportions of the individual components of MACE along with all-cause mortality. The χ^2 test was used to compare these clinical outcomes between patients with and those without significant stenosis anywhere along the graft. An additional end point was to determine the proportion of functional occlusion (TIMI 0, 1, or 2 flow) or significant stenosis in the RA grafts and SVGs. Finally, subgroup analyses were performed of the primary outcome with respect to diabetes status using McNemar's test within each strata. SAS, version 9.4 (SAS Institute Inc, Cary, NC) was used for all analyses. A