The second best arterial graft: A propensity analysis of the radial artery versus the free right internal thoracic artery to bypass the circumflex coronary artery

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Objective: We sought to determine if the radial artery (RA) or the free right internal thoracic artery (RITA) is the better conduit to bypass the circumflex coronary artery during coronary artery bypass grafting (CABG) using the left internal thoracic artery (LITA).

Methods: Propensity matching was performed on 2488 CABG-LITA patients from 2 affiliated centers, resulting in 528 pairs who received either a RA at one center or a free RITA at the other center to bypass the circumflex coronary artery from 1995 to 2009.

Results: Kaplan Meier estimated 1-, 5-, 10-, and 15-year survival rates were 99%, 95%, 85%, and 76% for RA patients, respectively, and 97%, 92%, 80%, and 71% for RITA patients, respectively ($P = .060$). Major adverse events (MAEs) were fewer in the RA group (7.6% vs 14.0%; $P = .001$) and use of the RA was a significant predictor of reduced MAEs (odds ratio [OR], 0.48; $P = .002$) in all patients and especially in diabetic (OR, 0.32; $P = .003$), older (OR, 0.40; $P = .009$), obese (OR, 0.15; $P < .001$), and chronic obstructive pulmonary disease (COPD) (OR, 0.05; $P = .016$) patients. However, survival was better with RA only in COPD (hazard ratio, 0.49; $P = .045$) and older (hazard ratio, 0.71; $P = .050$) patients. Overall RA patency (83.9%) was similar to RITA patency (87.4%) at a mean of 5.1 ± 3.8 years ($P = .155$).

Conclusions: Long-term survival is similar in CABG-LITA patients using either a RA or free RITA graft to bypass the circumflex coronary artery. RA grafting has fewer MAEs, a similar patency to RITA, and improves survival in older and COPD patients. The choice of the second arterial conduit should be guided by patient profiles and surgeon preferences. (J Thorac Cardiovasc Surg 2014;147:133-42)

ACD

The addition of a second arterial conduit improves long-term survival after coronary artery bypass grafting (CABG) using the left internal thoracic artery (LITA). Numerous studies[1-4] have shown a clear survival advantage of adding a right internal thoracic artery (RITA) compared with using the saphenous vein (SV). Similarly, multiple studies[5-8] have shown that the radial artery (RA) also has a strong survival benefit compared with SV grafting. Given the limitations of SV grafting, multiple arterial grafting is thus the increasingly recognized and recommended optimal treatment of multivessel coronary artery disease.[9]

However, it is unclear if the RA or the RITA is the better second arterial conduit[10-12] during CABG-LITA. Several investigators[13,14] have reported the RA to be the better option, some investigators[15] have found no difference, whereas others[16] have reported the RITA to be superior. All of these comparative studies had small numbers of patients, short- to midterm follow-up periods, and a high proportion of bypassing the right coronary artery with the second arterial graft. We sought to better define the second best arterial graft by comparing outcomes in propensity-matched patients receiving either a RA or free RITA to the circumflex coronary artery during CABG with LITA to the left anterior descending artery.

METHODS

Patients

We performed a retrospective cohort study of our 2 affiliated institutions' experiences using either the RA or the RITA to bypass the circumflex coronary artery during primary isolated CABG using the LITA to bypass the left anterior descending artery from January 1995 to January 2009. Beth Israel Medical Center (BIMC) and St. Luke's Roosevelt Hospital Center (SLR) are closely affiliated as part of Continuum Health Partners in New York, NY. Both centers maintain an identical New York State–mandated, prospectively collected database. BIMC used the RA as the primary second arterial conduit and SLR used the free RITA. Patients received additional

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Abbreviations and Acronyms

BIMC = Beth Israel Medical Center
BITA = bilateral internal thoracic artery
CABG = coronary artery bypass grafting
COPD = chronic obstructive pulmonary disease
HR = hazard ratio
LITA = left internal thoracic artery
MAE = major adverse event
OR = odds ratio
PS = propensity score
RCA = right coronary artery
RCT = randomized controlled trial
RITA = right internal thoracic artery
SITA = left internal thoracic artery and saphenous vein grafts
SLR = St. Luke's Roosevelt Hospital Center
SV = saphenous vein

SV grafts as needed. All data were sent to the New York State Department of Health and also are maintained in a separate institutional database using Microsoft Access (Redmond, Wash). This study was approved by the medical centers' respective Institutional Review Boards, which waived written informed consent.

RA use at BIMC was at first selective, with approximately 33% of CABG patients receiving a RA for indications of age younger than 65 years or unavailable venous conduit. Contraindications to RA use were hemodialysis or chronic renal insufficiency, Raynaud's disease, and, more recently, radial artery catheterization. Overtime, use gradually increased. Currently, 75% of all patients receive a RA at BIMC using a liberalized age limit of younger than 80 years. Average total RA use was 43% over the past 17 years whereas RITA use at SLR has been consistently very high at near 60%. There are no age restrictions at SLR and there were no contraindications to using a RITA graft. These different institutional grafting strategies resulted in a much younger RA population at BIMC than the SLR RITA group, as seen in Table 1.

A total of 6566 patients had isolated primary CABG using the LITA at BIMC (n = 4385) and at SLR (n = 2181) during the study period. Forty-one percent of these patients (2707) received a second arterial graft while the other 3859 patients received a LITA and SV grafts (SITA). RA and RITA were used mainly to bypass the circumflex vessels although the right coronary artery (RCA) occasionally was bypassed with these conduits. A total of 108 patients (98 at BIMC and 10 at SLR) receiving the second arterial graft to the RCA were excluded. The primary conduit to bypass the RCA was thus the SV. In addition, 111 patients (35 at BIMC and 76 at SLR) receiving both RA and RITA grafts were excluded. This resulted in 2488 patients at both institutions available for study: 1334 RA patients at BIMC and 1154 RITA patients at SLR.

Surgical Techniques

CABG was performed mostly on pump using cold blood cardioplegic arrest. Crystalloid cardioplegia was used early in the SLR experience. Off-pump surgery (1.1% of procedures at both BIMC and SLR) was performed when aortic disease precluded the safe use of cross-clamping or cardiopulmonary bypass. The RITA nearly always was used as a free graft. Both RA and RITA grafts were used as aortocoronary bypasses except if a lack of length or aortic disease precluded direct aortic anastomosis when the proximal anastomoses were performed on another RA, SV, or, rarely, LITA. BIMC performed the proximal anastomoses using a single cross-clamp technique whereas SLR used a partial occlusion clamp to perform the proximal anastomoses after removal of the cross-clamp. The RITA frequently was used as a sequential or Y graft 58% of the time for the RITA compared with only 18% of RA patients. In RA and RITA patients receiving more than 2 arterial grafts, an additional obtuse marginal, a large diagonal, or a ramus branch usually were grafted as the third arterial target vessel. SLR surgeons used the surgical microscope with 12× magnification for all anastomoses.

Our technique of radial artery harvest and preparation has been described previously.[17] Since 2000, we have harvested all conduits using an endoscopic approach. We previously found no advantage in open versus endoscopic harvesting.[18] The internal thoracic arteries were harvested as pedicled grafts at both institutions. Occasional mechanical or papaverine dilation of the ITA was performed at both institutions.

Study End Points

The primary end points of the study were all-cause mortality and perioperative major adverse events (MAEs), which included surgical death, stroke, myocardial infarction, sternal wound infection, sepsis, reoperation for bleeding, respiratory failure, and renal failure. The Social Security Death Index (www.Genealogybank.com) was searched in October 2012 and was used to identify patients who died after hospital discharge. Surgical mortality included all patients who died during the index hospitalization or within 30 days after surgery if discharged.

MAEs were collected prospectively and were defined by the Department of Health Cardiac Surgery Reporting System (http://www.health.ny.gov/statistics/diseases/cardiovascular/index.htmNYS). All MAEs occurred during the index hospitalization, except for sternal wound infection, which was reported up to 6 months postoperatively.

A secondary end point was graft patency. Symptom-driven cardiac catheterization was performed at our institutions on 17.7% of RA and 9.3% of RITA patients. We classified grafts as perfectly patent, diseased with more than 70% disease, or occluded. Grafts with string signs (diffuse narrowing of the graft to <1 mm or Thrombolysis in Myocardial Infarction [TIMI] flow of 1) were considered occluded.

Propensity Matching and Statistical Analysis

All analyses were conducted using Stata statistical software version 12.1 (release 12; Stata Corporation, College Station, Tex). Univariate comparisons between RA and RITA graft patients were conducted using *t* tests for normally distributed variates and 2-sample proportion tests for binary valued variates. Relationships with multivalued categoric variates were evaluated using χ^2 tests.

Because of selection bias in assignment of patients to specific graft types, a bias-reduction technique was used to allow testing of the relative effect of RA grafts on survival and other postoperative outcomes. A logistic propensity scoring model (based on the following significant predictors of treatment probability: age, sex, ethnicity, year of surgery, ejection fraction, priority, myocardial infarction, hypertension, chronic obstructive pulmonary disease [COPD], heart failure, number of grafts, number of arterial grafts, hemodialysis, and triple-vessel disease) was developed to summarize covariate information regarding treatment selection (RA vs RITA) into a single scalar value (propensity score [PS]) and subsequently was used in a nearest-neighbor, caliper-constrained matching technique.[19] A total of 1334 patients who had received a single RA graft were matched against a sample of 1154 patients who had received a single RITA graft. A total of 528 matched pairs (N = 1056) of RA and RITA graft recipients were identified and used for subsequent analysis.

Unadjusted long-term survival of the 2 covariate-matched patient/graft subgroups was evaluated using Kaplan-Meier estimates and the log-rank statistic. A Cox proportional hazard regression was conducted to evaluate the hazard ratio of RA versus RITA adjusted for a set of covariates and comorbidities that were selected in a stepwise fashion using backward elimination. The proportional hazard assumption was tested and found to have been met. The following independent variables were entered into

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