Late outcomes after radial artery versus saphenous vein grafting during reoperative coronary artery bypass surgery

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Objective: We investigated whether use of radial artery versus saphenous vein grafts during coronary artery bypass grafting reoperations is associated with a significant long-term survival benefit.

Methods: We reviewed a series of 347 consecutive coronary artery bypass grafting reoperations (1996–2007; 270 [78%] male patients; age, 65.3 ± 9.2 years). Internal thoracic artery grafts were used in 248 (71%) patients at the time of the first coronary artery bypass grafting operation and in 154 (44%) patients at reoperation. Patients were grouped based on whether a functional radial artery graft was present after coronary artery bypass grafting reoperation (radial artery cohort, n = 203 [59%]) or not (saphenous vein cohort, n = 144 [41%]). Median time to reoperation was similar for the radial artery (10.3 years) and saphenous vein (10.1 years) cohorts (P = .55). Angiographic data were used to ascertain the number and type of grafts that remained functional from initial coronary artery bypass grafting. Survival data (≤12 years) were time segmented based on multiphase hazard modeling at 90 days, and late survival was then analyzed by using proportional hazard Cox regression, with risk adjustment based on a radial artery–use propensity score computed from 48 covariates, including time to reoperation, month of surgical intervention, and total arterial and vein grafts after reoperation. Propensity-matched and propensity quintile comparisons were also done.

Results: Follow-up was similar for the radial artery versus saphenous vein cohorts (5.7 ± 3.4 vs 5.8 ± 4.0 years, P = .86), and 112 (50 in the radial artery and 62 in the saphenous vein cohorts) deaths were documented. Early mortality (≤90 days) did not differ for the radial artery (7.4%) and saphenous vein (12.5%) cohorts (P = .14). Unadjusted late outcomes were superior for the radial artery versus saphenous vein cohorts, with survival of 97.3% versus 92.9%, 84.9% versus 77.2%, and 74.1% versus 60.3% at 1, 5, and 10 years, respectively. Propensity-adjusted radial artery survival was superior, with a hazard ratio of 0.58 (P = .04), and this result was confirmed in a propensity-matched comparison.

Conclusions: We conclude that the use of radial artery as opposed to saphenous vein grafting for reoperative coronary artery bypass grafting, either with or without concomitant internal thoracic artery grafts, is associated with a substantial improvement in late survival. This benefit is likely derived from the increased overall number of arterial grafts. (J Thorac Cardiovasc Surg 2010;139:1511-8)

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Supplemental material is available online.

Evidence of the benefits of arterial grafts on late outcomes of coronary artery bypass grafting (CABG) has accumulated over the past 2 decades.[1-7] The left internal thoracic artery (LITA)/left anterior descending artery (LAD) graft has become the standard of care in patients undergoing primary CABG when LAD disease is present.[1,2] Several groups have also reported that further improvement in late survival is achieved by using additional arterial grafts, such as a second internal thoracic artery (ITA)[3,4] or radial artery (RA) graft,[5-8] as opposed to the conventional operation combining LITA/LAD with saphenous vein (SV) grafting.

Currently, there is a paucity of data on what is the optimal grafting method in case of reoperative CABG, particularly related to late outcomes. This has been confounded, in recent years, by the fact that many, if not a majority, of the patients presenting for repeat CABG might have had at least 1 ITA graft used during their first operation. The re-emergence of the RA graft and its demonstrated survival benefit after primary CABG put forth the possibility of a similar late RA

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This research is supported by departmental and institutional funds.

Disclosures: None.

Received for publication March 9, 2009; revisions received July 3, 2009; accepted for publication July 29, 2009; available ahead of print Oct 12, 2009.

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0022-5223/$36.00

doi:10.1016/j.jtcvs.2009.07.068

Abbreviations and Acronyms

CABG = coronary artery bypass grafting
ITA = internal thoracic artery
LAD = left anterior descending artery
LITA = left internal thoracic artery
RA = radial artery
SV = saphenous vein

benefit after CABG reoperation. In this study we analyzed the CABG reoperation experience at our institution with the primary aim of testing the hypothesis that use of RA grafting for repeat CABG will confer a significant long-term survival benefit when compared with SV grafting.

MATERIALS AND METHODS

This investigation is a retrospective analysis of a prospectively collected cardiac surgery database approved by the institutional review board, and informed consent was waived for this study. The database is collected and reported in accordance with the Society of Thoracic Surgeons' national database criteria.

Study Population

Patients undergoing reoperative CABG between January 1, 1996, and December 31, 2007, were considered for inclusion in this study. Patients were excluded if they underwent concomitant valve surgery, aortic surgery, or both during their operation or if they received ITA grafts exclusively ($n = 8$). The final study population consisted of 347 patients (270 [78%] male patients; age, 65.3 ± 9.2 years) divided into 2 subcohorts irrespective of their ITA grafting during reoperation (Table 1): the RA cohort consisted of 203 (59%) patients who either received 1 or more RA grafts at reoperation ($n = 200$, with or without additional SV grafts) or had remaining patent RA grafts from the first CABG ($n = 3$), and the SV cohort consisted of 144 (41%) patients with SV and no RA grafting at reoperation. Patients' demographic, comorbidity, and operative data for the RA and SV cohorts are summarized in Table 2. Annual volumes and their breakdown to the RA and SV cohorts are provided in Table E1.

The overall cohort included 283 (82%) isolated CABGs, whereas 64 underwent CABG combined with other noncardiac (eg, lung or carotid operations) or cardiac (eg, the maze procedure or ventricular aneurysm repair) procedures. Cardiopulmonary bypass was used in a large majority of patients, with only 23 (6.6%) of 347 study patients undergoing off-pump surgery. Over the 1996–2007 study period, the annual volumes varied between 9 and 48 cases per year (median, 32 cases). The initial CABG operation occurred over a period of 3 decades (1973–2005). The annual distribution of initial CABG and the corresponding increasing rate of ITA use at the time of the first operation are shown in Figure 1 (top). Median time to reoperation was similar for the RA (10.3 years) and SV (10.1 years) cohorts (Figure 1, bottom). A large majority of patients underwent their first reoperation CABG ($n = 333$ [96%]) compared with 12 who underwent their second (7 in the RA cohort and 5 in the SV cohort) and 2 (both in the RA cohort) who underwent their third reoperations.

Data Collection

Coronary catheterization reports before the index CABG reoperation were retrieved, and the status of previously placed grafts, including type of conduit and coronary targets, was recorded. For this study, a coronary graft was considered to be an anastomotic failure in case of (1) complete occlusion, (2) stenosis of 75% or greater, or (3) presence of extensive conduit narrowing or ''string sign.'' Long-term all-cause mortality data were secured from our service patient follow-up and verified from individual patient queries of the United States Social Security Death Index database (http://ssdi.genealogy.rootsweb.com) in September 2008. Database records were updated for missing death information when necessary. Allowing for a 3-month lag in the Social Security Death Index database, this corresponds to a minimum of 6 (December 2007 patients) and a maximum of 150 (January 1996 patients) months' follow-up.

Coronary Grafts

A summary of the number and type of completed grafts during the initial CABG operation of the RA and SV reoperative CABG cohorts is provided in Table 1. This table also shows the respective failure rates of these original grafts, as observed at the time of the index redo CABG operation. Expanded data, including the target-conduit use and graft failure data from the initial CABG operation, both combined and separated for the RA and SV cohorts, are provided in Tables E2 to E7. Lastly, grafting data at the index CABG reoperation are summarized for both cohorts in Table 2, whereas the related target-conduit use data from the reoperation are provided in Table E8. Note that for the 347 members of the total redo CABG population, 154 (44.3%) had ITAs used at reoperation, and this was similar for the 2 study cohorts (RA vs SV, 87/203 [43%] vs 67/144 [47%]; $P > .2$; Table 2). At least 1 functional (patent) ITA graft was present in 179 (88%) RA cohort and 118 (82%) SV cohort patients after the CABG reoperation. The 200 RA cohort patients received 260 radial grafts (1.3 per patient) achieved by means of bilateral radial use in 37 patients and construction of sequential radial grafts in 21 patients.

Surgical Technique

The approach to reoperative CABG was similar to that seen in other studies.[9,10] The surgical technique of RA harvesting and its intraoperative management in case of CABG reoperation was similar to that described for patients undergoing primary CABG.[5-8] Briefly, the presence of peripheral vascular disease was not a criterion for excluding patients from RA use per se. Hand collateral circulation and palmar arch status were assessed by using the modified Allen test and Doppler ultrasonography, respectively. Intraoperative plethysmography and oximetry were performed before establishing cardiopulmonary bypass. The RA was explored through a small incision, and harvesting was abandoned in case of small-vessel caliber, significant calcification, or both. Harvesting was done at the same time as the LITA dissection, with the RA removed as a pedicle without electrocautery (harmonic scalpel) and immersed in diluted papaverine. Hydrostatic and mechanical dilatation were not used to avoid intimal injury.

Bilateral RA harvesting was done in 37 (18.5%) of the 200 patients undergoing reoperative CABG with RA grafts. RA use as a single graft was predominant, whereas sequential RA grafts anastomosed to 2 or 3 target vessels were used in 21 (10.5%) patients. RA grafts were generally placed to target vessels greater than 1 mm in diameter, with a proximal stenosis of greater than 70% in a large majority of patients. The inflow into the sequential RA was in the overwhelming majority of cases from the aorta, unless aortic atherosclerosis or graft length issues precluded an RA to aorta anastomosis. The RA grafts coursed over the surface of the heart in gentle curves without acute angulation or kinking. The side-to-side anastomoses were constructed in 2 ways: (1) a diamond configuration in which the graft axis lies perpendicular to the axis of the target vessel or (2) a parallel configuration in which the graft and target axis are aligned. The target-vessel arteriotomy length in the diamond configuration was a function of the size of the RA and was tailored to prevent a seagull deformity. The distal anastomosis was constructed in either an anatomic (heel proximally or toe distally on the target vessel) or antianatomic (heel distally or toe proximally) fashion to facilitate a smooth course over the surface of the heart. The grafting strategy was predicated on maximizing the number of target vessels