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21-Year Survival of Left Internal Mammary Artery–Radial Artery–Y Graft

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ABSTRACT

BACKGROUND In 1999, Royse et al. reported on the left internal mammary artery, radial artery, Y-graft technique (LIMA-RA-Y), which achieves total arterial revascularization (TAR). However, the most common coronary reconstruction remains LIMA and supplementary saphenous vein grafts (LIMA + SVG).

OBJECTIVES The goal of this study was to conduct a survival comparison of LIMA-RA-Y versus the conventional LIMA + SVG.

METHODS Of the original 464 LIMA-RA-Y patients reported (1996 to 1998), 346 were from the Royal Melbourne Hospital. Survival at June 2017 was compared with a group of 534 patients from 1996 to 2003 from the same institution who received LIMA + SVG, or 5,800 patients who received TAR with different grafting configurations. Propensity score matching (PSM) was performed with 1:1 matching using 26 variables. Comparisons used Kaplan-Meier (KM) and Cox proportional hazards methods. LIMA-RA-Y was compared with LIMA + SVG in which all non–left anterior descending artery grafts were performed with either composite RA or aorta-coronary SVG with no use of right internal mammary artery. We also conducted a comparison of LIMA-RA-Y versus TAR.

RESULTS Baseline characteristics of the LIMA-RA-Y group (n = 346) compared with LIMA + SVG (n = 534) after PSM (n = 232 pairs) did not differ (3.3 ± 0.8 grafts per patient). Survival was worse for LIMA + SVG in the unmatched groups (KM, $p < 0.001$) and for PSM groups (KM, $p = 0.043$; Cox proportional hazards ratio: 1.3; 95% confidence interval: 1.0 to 1.6; $p = 0.038$). Survival did not differ between LIMA-RA-Y and other TAR (n = 5,800) patients before, or after, PSM (n = 332 pairs).

CONCLUSIONS Use of LIMA + SVG has worse survival than LIMA-RA-Y in achieving total arterial revascularization. (J Am Coll Cardiol 2018;72:1332–40) © 2018 by the American College of Cardiology Foundation.

As best as can be established, ~90% to 95% of coronary artery bypass grafting (CABG) worldwide is performed according to the technique using left internal mammary artery (LIMA) with supplementary saphenous vein grafts (SVG) (i.e., LIMA + SVG). We consider this operation as the "world standard operation" for CABG. The accepted evidence is that SVG frequently develop atherosclerosis over time and the incidence of graft failure approximates 50% 10 years' post-operation (1-4). This is the primary mechanism for the late failure of CABG.

At Royal Melbourne Hospital, the radial artery (RA) has been used in >80% of patients undergoing CABG since 1997, which achieves total arterial revascularization (TAR) >80% (5). The rationale for using arterial conduits instead of SVG is based on the expected late freedom from progressive conduit atherosclerosis and failure in arterial grafts, thereby leading to higher late patency and higher freedom from late ischemic

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cardiac events (5-7). However, it is clear from the low rates of TAR worldwide that this rationale is not widely held by most surgeons.

The conventional view is that most arterial conduits fail due to competitive flow in the coronary artery when anastomosed to a moderately stenosed coronary artery lesion (8,9). This scenario is also considered to be the primary mechanism by which failure of arterial grafts does not lead to clinically significant ischemic events (i.e., the myocardium is not dependent on graft blood flow at the time of failure) because the native coronary artery provides an adequate blood supply. Ischemia in this territory may occur later due to progression in severity of that coronary lesion; thus, early failure of the arterial conduit may not lead to late protection from ischemia. However, in the case of SVG, late failure may lead to myocardial ischemia because the target myocardium is dependent on graft blood flow at the time of failure, leading to clinically significant events of myocardial infarction, recurrence of angina, or heart failure (10).

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Suturing the RA to the LIMA as a composite graft (LIMA-RA-Y) is a technique that maximizes the efficiency of using an arterial conduit. Its primary purpose is to reliably avoid use of SVG with fewer conduits than alternative reconstruction strategies. The LIMA is used to revascularize the left anterior descending artery (LAD) territory; and the RA is used to revascularize the circumflex and right coronary artery (RCA) territories (**Central Illustration, Figure 1**). The right internal mammary artery was not used but is an alternative method of reconstruction using LIMA-RIMA-Y; harvesting the second internal mammary artery could result in higher rates of mediastinitis, however.

The original 1999 technique series described 464 patients with a single mortality (0.2%) at 30 days, demonstrating feasibility of this operation as well as early safety (11). Actuarial survival was 98% at 36.1 months. The aim of the present study was to examine the late (>10 years) survival of LIMA-RA-Y patients with a contemporaneous group of LIMA + SVG patients subjected to propensity score matching (PSM). We also tested if the survival for LIMA-RA-Y differs from other TAR reconstruction techniques.

METHODS

The study was approved by the Melbourne Health Human Research Ethics Committee and the Australian Institute of Health and Welfare; informed consent of the patient was waived. Of the 464 patients in the original paper (1996 to 1998) (11), 346 underwent their CABG surgery at the Royal Melbourne Hospital, and these subjects formed the follow-up group to ensure a single institution for all patients. During a contemporaneous time period (1996 to 2003), 534 patients from the same institution received LIMA + SVG. The groups underwent PSM (1:1), yielding 232 pairs (described in the Results). For the comparison with TAR during the same contemporaneous period from the same institution, 5,800 patients were included (after exclusion of the 346 LIMA-RA-Y patients), and PSM yielded 332 pairs. At the censor date, the study time frame post-operative was 13 to 21 years; thus, all surviving patients were in the "late period." All patients were routinely prescribed statins post-operatively.

The primary outcome was all-cause mortality. These data were obtained from the Australian Institute of Health and Welfare national death registry, and the censor date was June 1, 2017.

Continuous data and categorical data in unmatched data were compared with Student's 2-tailed *t*-tests and Fisher exact tests, respectively; paired Student's *t*-tests and McNemar's tests for paired samples were used in matched data. A Cox proportional hazards model (Cox) with multivariable (**Figures 2 and 3**) or univariable (**Central Illustration, Figure 4**) analysis was used to compare mortality between groups. These analyses were complemented with proportionality tests to check for the consistency of the hazard ratio in the time frame. Kaplan-Meier (KM) tests with stratified log-rank tests were used as appropriate. Significance was determined by p values < 0.05. Data were coded by using Microsoft Excel 2016 (Microsoft Corporation, Redmond, Washington) and analyzed by using SPSS IBM SPSS Statistics for Windows, version 23.0 (IBM SPSS Statistics, IBM Corporation, Armonk, New York) (12).

PSM was performed to mitigate possible selection bias at surgery and was calculated by using logistic regression of 26 variables with treatment assignment being the outcome. Matching was performed by using nearest neighbor (13) with a 1:1 ratio without replacement within a caliper of 0.05 of SD of propensity score logit. Strict matching between patients was done on patient sex. The variables included in the PSM analysis incorporated major cardiac risk factors (smoking, diabetes, hypercholesterolemia, hypertension, obesity, and family history of coronary

ABBREVIATIONS AND ACRONYMS

CABG = coronary artery bypass grafting

LAD = left anterior descending artery

LIMA = left internal mammary artery

LIMA-RA-Y = left internal mammary artery, radial artery, Y graft

LIMA + SVG = left internal mammary artery and supplementary saphenous vein graft

TAR = total arterial revascularization

PSM = propensity score matching

RA = radial artery

RCA = right coronary artery

SVG = saphenous vein graft

Y graft = composite graft between 2 or more conduits