Bilateral internal thoracic artery on the left side: A propensity score–matched study of impact of the third conduit on the right side

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Objective: This study was undertaken to evaluate long-term results of bilateral internal thoracic artery grafting with saphenous vein or another arterial conduit as the third conduit.

Methods: From September 1991 to December 2002, a total of 1015 patients underwent first isolated coronary artery bypass grafting for triple-vessel disease, with bilateral internal thoracic artery plus saphenous vein in 643 cases and bilateral internal thoracic artery plus arterial conduit in 372. A nonparsimonious regression model was built to determine propensity score, then sample matching (saphenous vein vs arterial conduit) was performed to select 885 patients (590 with saphenous vein, 295 with arterial conduit). Groups had similar preoperative and operative characteristics.

Results: Eight-year freedoms from cardiac death were significantly higher when saphenous vein was used (98.6% ± 0.5% with saphenous vein vs 95.3% ± 1.3% with arterial conduit, $P = .009$), but this difference was related exclusively to right gastroepiploic artery grafting (94.5% ± 1.6% vs saphenous vein, $P = .004$). This difference disappeared for radial artery grafting (97.6% ± 1.6% vs saphenous vein, $P = .492$). Cox analysis confirmed that supplementary gastroepiploic artery was an independent variable for lower freedoms from all-cause mortality and from cardiac death. Presence of high-degree stenosis (80%) appeared to influence this result.

Conclusions: In patients with triple-vessel disease undergoing first isolated coronary artery bypass grafting, supplementary venous grafts seem to provide more stability than gastroepiploic artery, which may even impair long-term outcome.

ACD

The number of coronary artery bypass grafting (CABG) procedures is decreasing because of increased use of percutaneous coronary revascularization, especially since the advent of drug eluting stents.[1] Conversely, the incidence of patients with triple-vessel coronary disease undergoing CABG has broadened remarkably in the last decade. In this scenario, surgeons must clearly identify any possible surgical strategy to improve long-term outcome. The superiority of bilateral internal thoracic artery (BITA) grafts relative to single internal thoracic artery (ITA) grafts has already been demonstrated,[2-5] especially when BITA, is grafted to coronary arteries on the left side.[4,5] The best supplementary graft for the right coronary artery (RCA) system, however, is still uncertain.

Right ITA, either in situ[6,7] or Y grafted,[8] does not offer any clinical or angiographic benefit relative to saphenous vein (SV). In particular, reduced right ITA patency has been observed when grafted to distal RCA system.[6,8] Although in the late 1990s some authors[9,10] supported the use of radial artery (RA) as complementary conduit in cases of left-side BITA grafting, long-term angiographic results are still uncertain.[11,12] Despite reasonable patency rate,[13] the use of right gastroepiploic artery (RGEA) should be limited to graft coronary stenosis of at least 70%; otherwise, the presence of an important coronary competitive flow may cause graft failure, even in patients with intact, patent grafts.[14,15]

To evaluate the graft of choice for revascularization of the RCA system when BITA is grafted to the left-side coronary system, this retrospective study compared long-term results of two groups of patients in which the third conduit was another arterial conduit (AC) or SV.

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MATERIALS AND METHODS

Population

From September 1991 to December 2002, a subset of 1015 (71%) of a total of 1496 patients at University of Chieti with triple-vessel coronary disease underwent first isolated CABG through a median sternotomy with BITA used for left-side myocardial revascularization. The RCA system was grafted with SV in 643 case (63.3%) and with AC in the remaining 372 (36.7%, RGEA in 258 and RA in 114). In the first part of the analysis, RA and RGEA conduits were pooled because of similar histologic structures,[16] similar reactivities to vasoconstrictor stimuli,[16] and similar low patency rates when grafted onto low-grade coronary stenoses, especially on the RCA system.[11,16] Further analysis was performed to evaluate separately the clinical impact of each type of AC. The three groups were similar with respect to most preoperative and operative features except for age (SV 63 ± 9 years vs RGEA 60 ± 9 years vs RA 61 ± 9 years, $P < .001$), number of anastomoses per patient (SV 3.6 ± 0.8 vs RGEA 3.0 ± 0.7 vs RA 3.4 ± 0.5, $P = .005$), prevalence of previous acute myocardial infarction (AMI, SV 46.2% vs RGEA 58.1% vs RA 61.4%, $P < .001$), prevalence of chronic renal failure (SV 3.4% vs RGEA 0.4% vs RA 0%, $P = .003$), and rate of off-pump CABG (SV 26.4% vs RGEA 17.4% vs RA 19.3%, $P = .009$).

Abbreviations and Acronyms

AC	= arterial conduit
AMI	= acute myocardial infarction
BITA	= bilateral internal thoracic artery
CABG	= coronary artery bypass grafting
CI	= confidence interval
ITA	= internal thoracic artery
RA	= radial artery
RCA	= right coronary artery
RGEA	= right gastroepiploic artery
ROC	= receiver operating characteristic
SV	= saphenous vein

A saturated regression model was solved to generate a propensity score for each patient, representing the probability of undergoing grafting with BITA plus SV. The propensity score was used to yield two propensity-matched groups by means of 2:1 sample matching; thus, a cohort of 885 patients (87.2%) was selected from the entire population as follows: 590 patients with BITA plus SV (91.8%) and 295 with BITA plus AC (79.3%) (RGEA in 208 cases and RA in 87). The two subsets showed similar preoperative and operative characteristics; moreover, no statistical differences were found among patients who received RA, RGEA, and SV grafts (Table 1). These cases were included in previous publications of ours. Use of our database was authorized by the institutional review board in October 2004. This authorization waived patient consent.

Surgical Technique

A contraindication for RA harvesting was a positive Allen test result.[17] RGEA was not harvested in presence of gastritis or ulcer, in cases of gallbladder calculosis, or in the expectation of further abdominal surgery. Whenever there was no contraindication to RA or RGEA harvesting, the arterial graft was chosen according to surgeon preference. Calcium blockers have been always used in patients undergoing harvest of RA or RGEA (60 mg 3 times/d, orally given for 6 months after the operation). The ITA was harvested in a pedicled fashion in the first 73 patients(8.2%) and as a skeletonized conduit in the remaining 812 (91.8%).[18] BITA was used as a Y graft[19] in 372 cases (42.0%), (BITA plus AC group n = 68, 23.1%, and BITA plus SV group n = 304, 51.5%, $P < .001$). The RA and RGEA were always harvested pedicled, as previously described[17]; the SV was always harvested from the lower leg in a skeletonized fashion. RGEA was grafted as in situ conduit. The left anterior descending coronary artery was grafted with ITA in all cases except 23, in which the vessel was extremely calcified or undersized and a diagonal branch was grafted instead of the left anterior descending coronary artery. RGEA was used preferably for posterior descending coronary artery grafting (75.9%) because of its anatomic position and its usually small size. RA was mainly grafted to the RCA (63.9%) because its size was better fitted to the RCA trunk. Most of the anastomoses performed with SV (61.4%) were onto the posterior descending coronary artery because of the SV's caliber from being harvested from the leg. Moreover, some peripheral branches, such as retroventricular, posterolateral, and acute marginal, were included as part of the RCA. Cardiopulmonary bypass was used in 676 cases (76.4%); myocardial revascularization was performed without cardiopulmonary bypass in the remaining 209 (23.6%). The on-pump and off-pump techniques used have previously been described.[20]

End Points

The primary end point was any possible difference between BITA plus SV and BITA plus AC in terms of long-term outcomes: 8-year freedoms from death from any cause, cardiac death, AMI, surgical or interventional reoperation, cardiac event, and any event. Cardiac death was defined as death that was cardiac related or occurred as sudden death. Cardiac event was defined as the occurrence of at least one of following events: cardiac death, AMI, or reoperation. Any event was defined as the occurrence of at least one of the following events: death from any cause, AMI, or reoperation. Myocardial infarction was defined as enzymatic elevation, electrocardiographic sign of necrosis, new akinetic segment or segments on echocardiogram, and ventricular arrhythmias not related to potassium ion. The secondary end point was long-term clinical outcome with respect to impairment by any of the three evaluated grafts.

Follow-up

All the patients were followed up in our outpatient clinic 3, 6, and 12 months after surgery and thereafter at yearly intervals. The most recent information was obtained by calling the patient or the referring cardiologist. Follow-up was 100% complete as of June 30, 2007. Median follow-ups were 97 months (25th–75th percentiles 78–120 months) overall, 88 months (70–102 months) for BITA plus SV, and 128 months (111–142 months) for BITA plus AC (131 months, 118–143 months for BITA plus RGEA and 116 months, 80–138 months for BITA plus RA, $P < .001$.

Statistical Analysis

Data are presented as mean ± SD. Statistical analysis comparing groups was performed with the Pearson χ^2 test (or the Fisher exact test) for categoric variables. Mann–Whitney U and analysis of variance tests (with post hoc analysis) were used for comparing continuous variables in cases of two (SV vs AC) or three (SV vs RGEA vs RA) groups, respectively. All the variables initially entered in the stepwise logistic regression to generate the propensity model have been reported previously.[20] The propensity score model fit and predictive power were evaluated with the Hosmer–Lemeshow goodness-of-fit (0.878) and *c*-statistic (0.901), respectively. The model was validated in 500 bootstrap samples. Eight-year survival curves were obtained with the Kaplan–Meier method; significant differences between groups were evaluated with log-rank tests. In cases of competing risks, cumulative incidences were reported. Time-to-event analysis was performed with a multivariable Cox proportional-hazard regression. Candidate variables[20] were tested by univariate approach; Variables with $P \leq .2$ were entered into the Cox regression. The final model was validated in 500 bootstrap samples; factors appearing in 50% or more of the analyses were considered reliably statistically significant. The results of Cox analysis were reported as hazard ratio, 95% confidence interval (CI), and P value. The optimal cutoff degree of RCA system stenosis to predict worse 8-year cardiac mortality was determined by receiver operating characteristic (ROC) curve analysis; area under the curve with corresponding 95% CI and P value along with sensitivity, specificity, and their respective 95% CIs were reported. Again, the results of ROC analysis were validated in 500 bootstrap samples. The SPSS software package (SPSS Inc, Chicago, Ill) was used.

RESULTS

Early Outcome

Thirty-day mortality was 1.8% (16 cases); 6 (0.7%) of these patients died of cardiac causes. AMI and cerebrovascular accident occurred in 11 (1.2%) and 14 (1.6%), respectively. The rate of aggregate negative primary end points (death from any cause, AMI, and cerebrovascular accident) was 4.0% (35 cases). Sixty-one patients (6.9%) had a major event (death, low output syndrome, AMI, cerebrovascular accident, acute renal failure, acute respiratory insufficiency, ventricular arrhythmias, abdominal complication). Early outcome was not statistically different among groups.