Total Arterial Myocardial Revascularization With Composite Grafts Improves Results of Coronary Surgery in Elderly: A Prospective Randomized Comparison With Conventional Coronary Artery Bypass Surgery

Claudio Muneretto, MD; Gianluigi Bisleri, MD; Alberto Negri, MD; Jacopo Manfredi, MD; Marco Metra, MD; Savina Nodari, MD; Lidia Culot, MD; Livio Dei Cas, MD

**Background**—Total arterial myocardial revascularization with composite grafts proved to enhance the long-term benefits of coronary surgery. We assessed the hypothesis that full arterial revascularization (FAR) may improve clinical outcome even in elderly and at short term.

**Methods and Results**—A prospective randomized study was designed to compare FAR with conventional coronary artery bypass grafting (CABG) surgery [left interval thoracic artery (LITA) on left anterior descending (LAD) plus additional saphenous vein grafts] with the following end points: early and late death, graft occlusion, reintervention, angina recurrence, and acute myocardial infarction (AMI). We enrolled 200 consecutive patients >70 years of age; population was equally divided at random in Group 1 (G1, FAR) and Group 2 (G2, Conventional). The groups resulted comparable with respect to all preoperative continuous and discrete variables and risk factors (Euroscore: G1 = 8.4 versus G2 = 8.1). No differences between G1 versus G2 were observed in terms of postoperative complications (perioperative AMI: 2% versus 3%), mean intensive care unit (ICU) (hours: 39 ± 11 versus 40 ± 9) and hospital stay (days: 6 ± 2 versus 7 ± 3) nor were there any differences in hospital mortality (G1 = 5% versus G2 = 4%). At the mean follow-up of 14 ± 5 months the incidence of angina recurrence was 3% in G1 versus 12% in G2. Angiographic controls of grafts showed a superior graft patency rate of all the arterial grafts when compared with saphenous vein grafts. Conventional CABG surgery was identified as incremental risk factor for angina recurrence and as predictor for graft occlusion.

**Conclusions**—Total arterial myocardial revascularization improved clinical outcome of patients undergoing coronary surgery in the elderly, whereas saphenous vein grafts negatively affected patient prognosis in terms of graft patency and freedom from late cardiac events. (Circulation. 2003;108[suppl II]:II-29-II-33.)

**Key Words:** aging • arteries • coronary disease • revascularization • surgery

Progressive advances in surgical techniques and perioperative care led to an increasing number of patients >70 years of age undergoing coronary surgery during the past decade.1,2 Despite the proven benefits of internal thoracic arteries (ITAs) on long-term outcome,3-4 the saphenous vein graft has been widely accepted as the conduit of choice for myocardial revascularization in the elderly, as a consequence of the reduced life expectancy of the elderly population and to concerns about excessive surgical invasiveness in this subset of patients when arterial grafts were used.5

In addition, patients >70 years of age hold a higher risk for postoperative morbidity and mortality, which is related not only to the aging process “per se” but also to the presence of several associated comorbidities.6

Many authors demonstrated that total arterial revascularization improved the clinical outcome of patients undergoing coronary artery bypass surgery when compared with the conventional technique (LITA on LAD plus additional saphenous vein grafts).3,4,7,8 However, none of the previous studies analyzed in a prospective and randomized study the advantages of total arterial grafting in elderly patients. Therefore, in the present study we evaluated at short- and mid-term the safety and usefulness of total arterial revascularization with composite grafts in patients aging >70 years.

**Methods**

**Patient Selection Criteria**

Two hundred consecutive patients undergoing coronary surgery and >70 years of age were assigned at random to Group 1 (G1: 100 pts., receiving total arterial myocardial revascularization with composite grafts) or to Group 2 (G2: 100 pts., receiving conventional CABG surgery, ie, LITA on LAD plus additional saphenous vein grafts).

We excluded from this study patients with left ventricular ejection fraction <25%, single vessels disease, emergency operations and high-risk patients with Euroscore >10. After undersigning informed
consent specific to the type of surgery, all of the patients were randomized in the 2 groups; the study protocol was approved by the Institutional Review Board.

Surgical Strategy
All of the patients underwent on-pump coronary artery bypass surgery through a standard sternotomy approach. Both of the ITAs were harvested as pedicled conduits; in patients undergoing Radial artery (RA) harvesting, we carried out a preoperative evaluation of the nondominant arm (Allen Test, oximetric plethysmography) in order to assess the adequacy of collateral flow from the ulnar artery. The RA was harvested preserving its satellite veins and surrounding connective tissue to minimize wall damage and risk of spasm. After systemic heparinization, both the ITAs and the RA were divided distally, and a solution of papaverine hydrochloride was applied topically (on the ITAs) or injected intraluminally (in the RA). When the RA was used as a free graft, it was maintained in situ until the related coronary anastomosis had to be performed in order to avoid arterial damage because of unnecessary storage.

Composite arterial grafts were realized always before cardiopulmonary bypass by an end-to-side anastomosis (with a 8/0 polypropylene running suture) of the right internal thoracic artery (RITA) and/or RA in a Y/T graft configuration to the fascial side of the in situ LITA.

We realized the composite arterial grafts according to three different configurations: 1) type 1 configuration was used in case of a dominant, not occluded right coronary artery; in this geometry the RITA is anastomosed as Y or T graft to the in situ LITA, whereas the RA is used as a free graft for the right coronary system.

In type 2 configuration the RA is anastomosed as a Y graft to the in situ LITA, and multiple sequential anastomoses are carried out in presence of multivessel disease; this configuration was used in presence of borderline stenosis of the obtuse marginal, occluded right coronary artery and in presence of low runoff of the target coronary vessels.

Type 3 configuration was mainly used when planned configuration type 1 or 2 could not be performed because of atheromatous lesions of the ascending aorta (switch from type 1 to type 3) or unfavourable anatomy of the posterolateral vessels (switch from type 2 to type 3); in this geometry 2 segments of RA or plus RITA are anastomosed end-to-side to the LITA, in order to obtain a double Y graft.

Standard extracorporeal circulation was then instituted, under mild hypothermia with a mean arterial blood pressure >50 mmHg. Distal anastomoses were performed end-to-side or side-to-side (diamond-shaped for sequential anastomoses) with a 8/0 polypropylene running suture. We performed proximal anastomoses under aortic side clamping with a 6/0 (for saphenous vein grafts) or a 7/0 (for arterial conduits) polypropylene running suture. The proximal anastomosis of the RA (free graft) on the ascending aorta was performed in most cases on a saphenous vein patch sewed on the ascending aorta, whereas we avoided the use of the RITA as a free graft on the ascending aorta.

In patients receiving RA grafts, Diltiazem was administered i.v. at a mean dose of 0.5–1.5 μg/Kg/min, and it was continued for the first 48 hours after surgery. Thereafter we administered Diltiazem (≥120 mg/day) orally for at least 6 months.

Follow-Up
Patient follow-up consisted of periodical 3-months visits up to at least 12 months. Patient information was also collected from the cardiologist of the patient and home physicians, and by telephone interview. We considered as end-points of the study: early and late death, graft occlusion, reintervention, recurrence of angina (ie, chest pain of Canadian cardiovascular score (CCVS) class II or higher; clinical symptoms were then confirmed by means of exercise test and myocardial perfusion imaging with Thallium-201/Technetium-99m), and incidence of early and late myocardial infarction.

### Table 1. Preoperative Characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>G 1</th>
<th>G 2</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (female)</td>
<td>46%</td>
<td>44%</td>
<td>0.88</td>
</tr>
<tr>
<td>Age (*)</td>
<td>76.9±4.1</td>
<td>77±3.8</td>
<td>0.85</td>
</tr>
<tr>
<td>Diabetes</td>
<td>40%</td>
<td>38%</td>
<td>0.88</td>
</tr>
<tr>
<td>Hypertension</td>
<td>69%</td>
<td>67%</td>
<td>0.88</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>38%</td>
<td>36%</td>
<td>0.88</td>
</tr>
<tr>
<td>Obesity</td>
<td>15%</td>
<td>12%</td>
<td>0.67</td>
</tr>
<tr>
<td>COPD</td>
<td>30%</td>
<td>32%</td>
<td>0.87</td>
</tr>
<tr>
<td>Creatinine clearance &lt;50 ml min</td>
<td>19%</td>
<td>20%</td>
<td>1</td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
<td>7%</td>
<td>7%</td>
<td>0.78</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>33%</td>
<td>31%</td>
<td>0.88</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>32%</td>
<td>31%</td>
<td>1</td>
</tr>
<tr>
<td>Recent MI (&lt;90 days)</td>
<td>47%</td>
<td>44%</td>
<td>0.77</td>
</tr>
<tr>
<td>Inotropes pre-op</td>
<td>6%</td>
<td>7%</td>
<td>1</td>
</tr>
<tr>
<td>Ejection fraction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30–50%</td>
<td>35%</td>
<td>40%</td>
<td>0.55</td>
</tr>
<tr>
<td>&lt;30%</td>
<td>15%</td>
<td>12%</td>
<td>0.67</td>
</tr>
<tr>
<td>Redo surgery</td>
<td>6%</td>
<td>5%</td>
<td>1</td>
</tr>
<tr>
<td>Euroscore (*)</td>
<td>8.4±2.5</td>
<td>8.1±2.3</td>
<td>0.37</td>
</tr>
</tbody>
</table>

G 1: Total Arterial Revascularization—G 2: Conventional Revascularization
COPD: Chronic Obstructive Pulmonary Disease; MI: Myocardial Infarction.
(*) value expressed as mean±SD.

Statistical Analysis
Comparisons of variables between the patient groups were assessed using the χ² test with Yates correction for discrete variables and the unpaired t test for continuous variables. Data for continuous variables are expressed as mean ± SD. A probability value <0.05 was considered statistically significant.

Multivariate logistic regression analysis was used to assess the independent predictors of graft occlusion. Finally, to identify the independent predictors of event-free survival, multivariate analysis was carried out with the Cox proportional hazard regression model using the variables significant at the P<0.1 level at univariate analysis.

The statistical analysis was calculated with the StatSoft (Version 5.1, ‘97 Edition, StatSoft Italia S.r.l.).

Results

Preoperative Data
Patient preoperative characteristics are shown in Table 1. The 2 groups resulted similar at univariate analysis for all of the continuous and discrete variables; in particular, no significant differences were observed in terms of operative high-risk profile, as assessed by the Euroscore system (mean: G1=8.4±2.5 versus G2=8.1±2.3, P=0.37).

Intraoperative Data and Early Outcome
No differences between the groups were observed with regards to aortic cross clamping time (G1: 33.8±10 minutes versus G2: 32.6±7.2 minutes), whereas the cardiopulmonary bypass time was greater in patients receiving conventional coronary surgery (G1: 58.2±16 minutes versus G2: 77.5±9.7 minutes, P<0.001), as a consequence of the additional time required to perform the proximal anastomoses of the venous grafts. We were able to achieve a similar completeness of revascularization in the 2 groups (mean number of anasto-
moses: G1: 2.44±0.8 versus G2: 2.46±0.6); the mean target vessel diameters were 1.5±0.3 mm and 1.6±0.2 mm in Group 1 and Group 2, respectively.

The 3 different configurations of composite arterial grafts were used in 5% of patients for type 1 configuration (this geometry was restricted to few cases without atheromatous disease of the ascending aorta) and in 60% and 35% of patients for type 2 and 3 geometries, respectively.

Additional intraoperative data are shown in Table 2. We did not observe any differences with regards to mechanical ventilation time (G1: 31±5 hours versus G2: 32±4 hours, P=0.12) and ICU stay (G1: 39±11 hours versus G2: 40±9 hours, P=0.48) nor with respect to the incidence of major postoperative complications, as shown in Figure 1.

There were no significant differences in terms of hospital mortality between the groups (G1: 5 pts. versus G2: 4 pts.), and also the causes of death were similar in the 2 groups: sepsis (G1: 2 pts. versus G2: 1 pt.), multiple organ failure (G1: 2 pts. versus G2: 2 pts.), and abdominal ischemia (G1: 1 pt. versus G2: 1 pt.). Cerebrovascular complications occurred more frequently in patients undergoing conventional coronary surgery, but this difference failed to reach a significant probability value (G1: 1 pt. versus G2: 5 pts., P=0.21): all of the patients who developed cerebrovascular accidents had ascending aorta manipulation for proximal graft anastomosis.

Moreover, 9 patients of Group 2 developed a specific group-related complication (ie, leg wound complication) related to saphenous vein graft harvesting; most of these patients had diabetes (7/9 pts., 77.7%). Conversely, no arm wound complication was observed in relation to RA harvesting. Moreover, the incidence of sternal wound complications was identical in both groups (G1=1% versus G2=1%), despite the use of double mammary harvesting in 31% of pts. in Group 1.

**Mid-Term Results**

We evaluated all of the the hospital survivors (G1: 95 pts. versus G2=96 pts.) at 2, 6, and 12 months postoperatively (mean follow-up, 15±4 months) by means of clinical examination and cycloergometric test. Angiograms were carried out at random and in patients with a positive or doubtful cycloergometric test. At follow-up, the incidence of cardiac-related events was higher in patients receiving conventional coronary surgery, as shown in Figure 2. Coronary angiography (mean follow-up period: 18±2 months) was performed on 91 pts. in Group 1 and 89 pts. in Group 2 (95.7% and

**TABLE 2. Perioperative data**

| Variable                  | G 1             | G 2             | P  
|---------------------------|-----------------|-----------------|-
| Intraoperative Data       | Mean±SD         | Mean±SD         |     
| N° of vessels grafted     | 2.44±0.8        | 2.46±0.6        | 0.84 |
| Cross-clamping time (min) | 33.8±10         | 32.6±7.2        | 0.33 |
| CPB time (min)            | 58.2±16         | 77.5±9.7        | <0.001 |
| Conduits*                 | N°              | N°              |     |
| LITA                      | 100             | 100             |     |
| RITA                      | 31              | 0               |     |
| Radial artery             | 60              | 0               |     |
| Saphenous vein graft      | 0               | 146             |     |
| Early post-operative data |                 |                 |     |
| Ventilation Time (hours)  | 31±5            | 32±4            | 0.12 |
| ICU stay (hours)          | 39±11           | 40±9            | 0.48 |

G 1: Total Arterial Revascularization—G 2: Conventional Revascularization
CPB: cardiopulmonary by-pass; LITA: left internal thoracic artery; RITA: right internal thoracic artery; ICU: intensive care unit.
Conduits*: some conduits were used as sequential grafts for multiple anastomoses.

Figure 1. The incidence of major postoperative complications is shown.
92.7% of hospital survivors, respectively. In Group 1 evaluation was carried out on 91 LITAs (all anastomosed on 91 LADs, plus 7 sequential anastomoses on diagonal branches), 55 RAs (anastomosed either termino-laterally or sequentially on 8 diagonal branches, 38 obtuse marginal branches, and on 26 right coronary arteries), and 21 RITAs (anastomosed either termino-laterally or sequentially on 8 diagonal branches, 24 obtuse marginal branches, and on 20 right coronary arteries); in Group 2 89 LITAs (anastomosed on 89 LADs and sequentially on 6 diagonal branches) and 116 saphenous vein grafts (anastomosed either termino-laterally or sequentially on 3 diagonal branches, 65 obtuse marginal branches, and 55 right coronary arteries). Angiograms revealed the following graft patency rates: in Group 1 grafts patency was 99% for LITA (1 occluded graft on LAD), 100% for RITA, and 96.7% for RA (2 occluded grafts on the circumflex system); in Group 2 grafts patency was 100% for LITAs and 84% for saphenous vein grafts (2 occluded grafts on diagonal branches, 10 on obtuse marginal branches, and 8 on right coronary arteries).

When we used the Kaplan-Meier analysis to evaluate the survival-free from recurrent angina or myocardial infarction, we observed a significantly improved outcome in patients undergoing total arterial myocardial revascularization; in addition, diabetes and hyperlipidemia had a negative impact on clinical outcome especially of patients receiving saphenous vein grafts. (Figure 3B)

The only variables significantly associated with graft occlusion both at univariate and multivariate stepwise regression analysis were the presence of diabetes, hyperlipidemia, and conventional coronary surgery (diabetes: odds ratio [OR]=1.17, 95% confidence interval [CI]=1.10–1.24, P<0.0001; hyperlipidemia: OR=1.10, 95% CI=1.02–1.18, P=0.022; conventional surgery: OR=1.16, 95% CI=1.08–1.23); moreover, at the Cox proportional hazard model, late cardiac related events were also significantly affected by the presence of saphenous vein grafts, hyperlipidemia, and diabetes (saphenous grafts: hazards ratio [HR]=2.29, 95% CI=1.49–3.08, P=0.041; hyperlipidemia: HR=2.10, 95% CI=1.32–2.89, P=0.062; diabetes: HR=2.87, 95% CI=2.05–3.69, P=0.011).

**Discussion**

The percentage of patients undergoing coronary surgery >70 years of age has been steadily increasing during the past 10 years, mainly as a consequence of the progressive advances in medical care. Several authors reported about the safety and usefulness of cardiac surgical procedures in the treatment of the elderly population, which is progressively representing the largest fraction of patients undergoing coronary artery bypass surgery. Coronary surgery has been associated with an higher risk of perioperative morbidity and mortality in the elderly, when compared with younger populations.

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**TABLE 3. Multivariate Analysis for Graft Occlusion and Late Cardiac Events**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>95% Confidence Intervals</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graft occlusion (multivariate stepwise regression analysis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.17</td>
<td>1.10–1.24</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>1.10</td>
<td>1.02–1.18</td>
<td>0.022</td>
</tr>
<tr>
<td>Venous grafts</td>
<td>1.16</td>
<td>1.08–1.23</td>
<td>0.001</td>
</tr>
<tr>
<td>Late cardiac events (Cox proportional hazard model)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>2.87</td>
<td>2.05–3.69</td>
<td>0.011</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>2.10</td>
<td>1.32–2.89</td>
<td>0.062</td>
</tr>
<tr>
<td>Venous grafts</td>
<td>2.29</td>
<td>1.49–3.08</td>
<td>0.041</td>
</tr>
</tbody>
</table>

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Figure 2. At a mean follow-up of 15±4 months patients who received total arterial myocardial revascularization showed a better clinical outcome.

![Figure 2](image-url)
however, the greater operative risk in elderly patients seems
to be not only because of age, per se, but mostly related to the
presence of several associated comorbidities.\textsuperscript{14–17}

Despite the demonstrated advantages of myocardial revas-
cularization with arterial grafts,\textsuperscript{3–4} the majority of surgeons
preferred the use of saphenous vein grafts in an attempt to
reduce surgical invasiveness and the operative risks in the
elderly population; conversely, Morris et al\textsuperscript{5} reported their experience in the use of LITA on LAD in octogenarians,
showing an improved mid- and long-term outcome when
compared with saphenous vein grafts and, therefore, suggest-
ing to extend the already proven benefits of arterial revascu-
larization even in the elderly.

Our study was designed to evaluate the safety and the
advantages of total arterial myocardial revascularization in
comparison with the conventional technique (LITA on LAD
plus additional saphenous vein grafts) in elderly patients
scheduled for isolated coronary surgery. This study was
designed as a prospective randomized evaluation in order to
allow a comparison of 2 different surgical techniques in a
similar group of patients, avoiding selection bias. We adopted
only few exclusion criteria (left ventricular ejection fraction
\(<25\%\), emergency CABG, single vessel disease, and patients
with an Euroscore \(>10\)) in an attempt to avoid an unpre-
dictable distribution of high-risk patients in the 2 groups, thus
affecting the reliability of the study. Consistently with previ-
ous studies,\textsuperscript{2,3,5,7} also our patients had an higher prevalence of
renal dysfunction, cerebrovascular disease, chronic obstruc-
tive pulmonary disease, and diabetes when compared with the
younger CABG population. With the exception of diabetes,
whose prevalence was higher in our study group, compared
with other studies, the prevalence of concomitant diseases
was similar to that reported in previous studies.\textsuperscript{2,5}

Primarily our results demonstrate the safety of total arterial
myocardial revascularization in the elderly population, be-
cause the early results in Group 1 were similar to those of
Group 2 in terms of completeness of myocardial revascular-
ization, postoperative morbidity, and hospital mortality;
moreover, patients receiving total arterial myocardial revas-
cularization with composite grafts had a significant shorter
cardiopulmonary bypass time (as a consequence of the
absence of proximal anastomoses) and less cerebrovascular
accidents (because ascending aorta manipulation is mini-
mized), even if the difference between the groups did not
reach a statistical significance.

Moreover, the mid-term outcome of patients in Group 1
was significantly better than Group 2 in terms of recurrence of
angina/myocardial infarction, graft occlusion, and percu-
taneous transluminal coronary angioplasty reintervention,
therefore showing a superior actuarial freedom from late
cardiac events at Kaplan-Meier analysis.

Finally, when we evaluated the impact of associated comor-
bidities on the outcome of elderly patients, we observed that
saphenous vein grafts (conventional technique), diabetes, and
hyperlipidemia were able to affect outcome only of patients
belonging to Group 2; in fact, multivariate analysis identified
diabetes, saphenous vein grafts, and hyperlipidemia as independ-
ent predictors for graft occlusion and the same variables were
also found to be independent risk factors for angina recurrence
and myocardial infarction using the Cox regression model. At
any time interval of the follow-up there was evidence that
patients receiving total arterial grafts had a lower incidence of
late cardiac events when compared with patients receiving
saphenous vein grafts.

In conclusion, this study demonstrates the favorable results
of total arterial myocardial revascularization in the elderly, in
terms of clinical outcome, when compared with the conven-
tional technique, particularly in presence of associated com-
orbidity as diabetes and hyperlipidemia, which are very
common in this subset of patients.

Moreover, extremely diseased coronary arteries and poor
quality saphenous veins are more likely to be found in elderly
patients and, therefore, the conventional technique may be
less suitable for a safe and effective myocardial revascular-
ization than total arterial revascularization.

References

in the elderly using beating heart coronary surgery. \textit{Ann Thorac Surg}.

2. Craver JM, Puskas JD, Weintraub W, et al. 601 octogenarians undergoing
cardiac surgery: outcome and comparison with younger age groups. \textit{Ann

3. Lytle BW, Blackstone EH, Loop FD, et al. Two internal thoracic artery

mammary artery grafts: 10-year outcome analysis. \textit{Ann Thorac Surg}.


patients over 70 years old: the influence of age and surgical technique on

grafts for total arterial myocardial revascularization: a prospective and ran-

with an internal thoracic artery and radial artery \textit{T} graft. \textit{Ann Thorac Surg}.

Society of Thoracic Surgeons national database experience. \textit{Ann Thorac


11. Akins CW, Daggett WM, Vlahakes GJ, et al. Cardiac operations in

12. Edmunds LH Jr, Stephenson LW, et al. Open-heart surgery in octoge-

mortality in octogenarians undergoing coronary bypass. \textit{Ann Thorac

predict hospital length of stay in patients older > 60 years old. \textit{Circu-

15. Mohan R, Ansuel BJ, Walter PJ. Coronary artery bypass grafting in the
elderly: a review of studies on patients older than 64, 69 or 74 years.


17. Khan S, Kuper JM, Matloff JM, et al. Interaction of age and of pre-
operative risk factors in predicting operative mortality for coronary

and operative mortality in elderly patients undergoing coronary artery
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