Twenty-year outcomes of coronary artery bypass grafting utilizing 3 in situ arterial grafts

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ABSTRACT

Objective: The added value of total arterial revascularization in coronary artery bypass grafting becomes particularly apparent when evaluating long-term results. We previously reported on our 10-year outcomes of total arterial revascularization using bilateral internal thoracic and gastroepiploic arteries as in situ grafts in patients with 3-vessel disease. This study aimed to increase the follow-up period to 20 years.

Methods: We updated clinical outcomes of 201 patients operated on between 1992 and 2002. At that time, the technique was primarily performed in patients with a longer life expectancy. Primary end points were overall survival and freedom from the composite of major adverse cardiac events. Secondary end points were the separate cardiac events.

Results: Extended follow-up included all patients. The median follow-up time was 19.2 years (interquartile range, 16.2-20.0). The respective 15- and 20-year Kaplan-Meier estimated survival probabilities were 73.9% (95% confidence interval [CI], 67.2%-79.5%) and 63.5% (95% CI, 55.7%-70.4%) for overall survival and 57.9% (95% CI, 50.7%-64.5%) and 47.9% (95% CI, 40.1%-55.3%) for freedom from major adverse cardiac events. The respective estimated cumulative incidences at 15 and 20 years were 7.0% (95% CI, 3.5%-10.6%) and 7.8% (95% CI, 4.0%-11.6%) for myocardial infarction, 8.6% (95% CI, 4.7%-12.5%) and 9.3% (95% CI, 5.2%-13.3%) for percutaneous reintervention, 7.0% (95% CI, 3.5%-10.5%) and 7.0% (95% CI, 3.5%-10.5%) for reoperation, 8.6% (95% CI, 4.7%-12.6%) and 12.9% (95% CI, 7.6%-18.2%) for cardiac death, and 10.8% (95% CI, 6.5%-15.2%) and 15.2% (95% CI, 9.8%-20.6%) for death from other causes.

Conclusions: The use of in situ bilateral internal thoracic and gastroepiploic arteries provides outstanding 15- and 20-year survival and cardiac event-free survival probabilities. Further studies are needed in older patients with more severe comorbidities. Nevertheless, the results from this and scarce other studies on 15- to 20-year outcomes of total arterial revascularization suggest that cardiac surgeons should embrace the application of total arterial grafting to further reduce the risks of long-term cardiac events, especially during the second decade after surgery. (*J Thorac Cardiovasc Surg* 2019;157:2228-36)

Total arterial revascularization with 3 in situ grafts.

Central Message

The use of in situ bilateral internal thoracic and gastroepiploic arteries reduces the risks of long-term cardiac events, especially during the second decade after coronary artery bypass grafting.

Perspective

There are scarce published data on very long-term outcomes (15 years or longer) after coronary artery bypass grafting with at least 2 arterial grafts. The results from this study and similar studies with sufficient follow-up time suggest that cardiac surgeons should embrace the application of total arterial grafting to further reduce the risks of long-term cardiac events.

See Commentaries on pages 2237 and 2240.

In evaluating outcomes of coronary artery bypass grafting (CABG), multiple studies have demonstrated the

long-term survival benefit of the use of bilateral internal thoracic artery (BITA) grafts over that of a single internal thoracic artery (SITA) supplemented with saphenous vein grafts (SVGs).¹⁻⁷ Moreover, the exclusive use of arterial

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Abbreviations and Acronyms

BITA	= bilateral internal thoracic arteries
CABG	= coronary artery bypass grafting
CCSA	= Canadian Cardiovascular Society Angina Grading Scale
COPD	= chronic obstructive pulmonary disease
CX	= circumflex artery
GEA	= right gastroepiploic artery
ITA	= internal thoracic artery
LAD	= left anterior descending artery
MACE	= major adverse cardiac events
MI	= myocardial infarction
PCI	= percutaneous coronary intervention
RCA	= right coronary artery
SITA	= single internal thoracic artery
SVG	= saphenous vein graft

grafts seems to confer an incremental survival benefit relative to BITA grafting with SVG.^{8,9} To achieve total arterial revascularization in patients with 3-vessel disease, the right gastroepiploic artery (GEA) graft may be a good option to supplement BITA grafts.^{10,11} This third arterial conduit has potential advantages over the BITA Y-graft strategy or the use of the radial artery because it is a third in situ graft.

In 2004, we reported the short- and long-term results of total arterial revascularization with BITA and GEA grafts in patients with 3-vessel disease and showed an excellent 10-year survival probability of 87%.¹² However, although the survival and cardiac event-free survival benefits seemed undeniable compared with BITA grafting supplemented with SVG, the potential very long-term advantages (after 15 years of follow-up) of this revascularization strategy are not yet well established. The aim of the present study was to report the extended long-term follow-up data of the previous patient cohort.

MATERIAL AND METHODS

Study Design

The current study is an analysis based on the extended follow-up of patients included in a previous study on BITA plus GEA grafting to achieve total arterial revascularization.¹² The extended follow-up study was approved by the ethics committees of the involved hospitals.

Patient Population

Between November 1992 and May 2002, 201 patients with 3-vessel disease underwent total arterial revascularization with the use of BITA and GEA as in situ grafts by 1 surgeon (GT) in 3 Dutch hospitals (Catharina Hospital Eindhoven, St Antonius Hospital Nieuwegein, and Leiden University Medical Center).

This revascularization strategy was preferentially used in patients with a life expectancy of more than 10 years. Contraindications were severe chronic obstructive pulmonary disease (COPD), severe or poorly

controlled insulin-dependent diabetes mellitus, cardiogenic shock, extreme chest deformities, and previous gastrointestinal resection. Previous cholecystectomy was not a contraindication.

Surgical Technique

The surgical technique regarding the harvesting, routing, and treatment of the BITA and GEA grafts has been described previously.¹³ All patients were operated on with the use of extracorporeal circulation. Two graft configurations were used. In 157 patients (78%), the left internal thoracic artery (ITA) was placed to the left anterior descending artery (LAD) system, the right ITA through the transvers sinus to the circumflex artery (CX) system and the GEA to the right coronary artery (RCA) system (Figure 1, A) (Video 1). In 44 patients (22%), the right ITA was placed to the LAD system in front of the aorta, the left ITA to the CX system and the GEA to the RCA system (Figure 1, B). An endarterectomy was performed in 13 patients (6%).

All patients received lifelong antiplatelet therapy postoperatively. Postoperative statin prescription in our patient cohort became common practice over the years.

Follow-up

Follow-up information on major adverse cardiac events (MACE) was obtained by telephone interviews conducted by GT with the patients, family members, or their referring cardiologists when the patient was unreachable. The common closing date for follow-up was March 1, 2015. All outcomes of interest were confirmed by source documentation collected from referring cardiologists or general practitioners.

End Points and Definitions

The primary outcomes were overall survival and freedom from the composite end point of MACE, defined as the first occurrence of myocardial infarction (MI), percutaneous coronary intervention (PCI), re-CABG, cardiac death, or death from other causes. Secondary outcomes were the separate clinical events MI, PCI, re-CABG, cardiac death, and death from other causes. Cardiac death was defined as death due to acute cardiac arrest, MI, sudden death, progressive congestive heart failure, and unknown causes. Deaths occurring before hospital discharge or within 30 days were considered cardiac deaths. MI was defined by a rise in creatine kinase-MB isoform by 3 times the upper limit of normal, enzymatic elevation of serum glutamic oxaloacetic transaminase ≥ 100 , and/or troponin T $>1 \mu\text{g/L}$ and development of new Q-wave associated with creatine kinase-MB elevation consistent with myocardial necrosis.

Statistical Analysis

Continuous data are presented as mean $\pm$ standard deviation or as median (interquartile range [IQR]), as appropriate. Categorical data are presented as number and percentage. Median and IQR of follow-up time were calculated using the reverse Kaplan-Meier method.¹⁴ Overall survival and event-free survival probabilities were estimated using the Kaplan-Meier method and reported as percentage (95% confidence interval [CI]). For first event analysis of the secondary end points, the components of MACE, cumulative incidence probabilities were estimated accounting for competing risks.¹⁵ For each component of MACE, all other components of MACE were used as competing risks. Multivariable Cox regression analysis with forward stepwise selection was used to examine predictors of the primary end points. The predictor variables considered were age, gender, hypertension, hyperlipidemia, diabetes mellitus, peripheral vascular disease, COPD, smoking history, obesity (body mass index >25), history of MI, prior CABG, unstable angina (Canadian Cardiovascular Society Angina Grading Scale [CCSA] class IV), left ventricular dysfunction (ejection fraction $<50\%$), and left main stenosis. Probabilities used for entrance and removal in the stepwise method were 0.05 and 0.10, respectively. All analyses included in-hospital outcomes.

FIGURE 1. Total arterial revascularization with 3 in situ grafts. A, Left internal thoracic artery (LITA) to the left anterior descending artery (LAD) system, right internal thoracic artery (RITA) to the circumflex artery (CX) system, and right gastroepiploic artery (GEA) to the right coronary artery (RCA) system. B, RITA to the LAD system, LITA to the CX system, and GEA to the RCA system.

Survival and competing risks analyses were performed using the *prodim* package version 1.6.1 for R version 3.4.2 (R Foundation for Statistical Computing, Vienna, Austria). All other statistical analyses were performed using IBM-SPSS Statistics for Windows version 23.0 (IBM-SPSS Inc, Armonk, NY).

RESULTS

Characteristics of the Study Population and Follow-up

Patient characteristics of the study cohort are summarized in [Table 1](#). Details on the site of the anastomoses and in-hospital outcomes are described in our previous report.¹² No patient was lost to follow-up. Median follow-up time was 19.2 years (IQR, 16.2-20.0 years). The percentages of patients with more than 15 and 20 years of follow-up were 82.1% and 26.6%, respectively.

Primary Outcomes

During follow-up there were 59 deaths, 27 from a cardiac cause. Noncardiac death included malignancy in 19 patients, pulmonary failure in 6 patients, and other causes in 7 patients. For the total study cohort (N = 201), estimated overall survival probabilities at 10, 15, and 20 years were 84.0% (95% CI, 78.1%-88.4%), 73.9% (95% CI, 67.2%-79.5%), and 63.5% (95% CI, 55.7%-70.4%), respectively ([Figure 2, A](#)) ([Table 2](#)) and estimated freedom from MACE probabilities at 10, 15, and 20 years were

69.4% (95% CI, 62.5%-75.3%), 57.9% (95% CI, 50.7%-64.5%), and 47.9% (95% CI, 40.1%-55.3%), respectively ([Figure 2, B](#)).

Multivariable Cox regression analysis in the total study cohort revealed 5 independent predictors of all-cause death: age (hazard ratio [HR], 1.07; 95% CI, 1.02-1.11; $P = .002$), obesity (HR, 2.08; 95% CI, 1.20-3.59; $P = .009$), smoking history (HR, 2.08; 95% CI, 1.26-3.44; $P = .004$), COPD (HR, 2.26; 95% CI, 1.08-4.77; $P = .032$), and CCSA class IV (HR, 1.92; 95% CI, 1.11-3.33; $P = .021$), and revealed 2 independent predictors of MACE: age (HR, 1.03; 95% CI, 1.00-1.07; $P = .031$) and CCSA class IV (HR, 1.90; 95% CI, 1.23-2.94; $P = .004$).

Secondary Outcomes

Ten patients experienced MI during follow-up. The estimated cumulative incidences for MI in the total study cohort at 10, 15, and 20 years were 6.5%, 7.0%, and 7.8%, respectively ([Figure 3, A](#)) ([Table 2](#)). Twenty-seven patients underwent PCI after hospital discharge. In 25 patients, a native coronary artery was treated (6 previously ungrafted vessels). PCI concerned a vessel of the RCA system in 13 patients, the CX system in 7 patients, and the LAD system in 5 patients. In 2 patients, a PCI of a left ITA graft was performed. The estimated cumulative incidences for PCI in the total study cohort at 10, 15, and

VIDEO 1. Surgical technique of total arterial revascularization utilizing 3 in situ grafts. In the video, the off-pump technique is used because nowadays this is the preferred technique of the first author for this type of revascularization. Video available at: [https://www.jtcvs.org/article/S0022-5223\(18\)33450-0/fulltext](https://www.jtcvs.org/article/S0022-5223(18)33450-0/fulltext).

20 years were 5.5%, 8.6%, and 9.3%, respectively (Figure 3, B). Four patients underwent re-CABG after hospital discharge. Two patients received an SVG on the LAD with the off-pump technique at, respectively, 9 and 14 years after the index surgery. One patient received an SVG on the RCA in conjunction with an aortic valve replacement 8 years after surgery. One patient received an SVG on the LAD and an SVG on the RCA together with mitral and tricuspid valve repair at 11 years after surgery. The estimated cumulative incidences for re-CABG in the total study cohort at 10, 15, and 20 years were 6.5%, 7.0%, and 7.0%, respectively (Figure 3, C). The estimated cumulative incidences for cardiac death in the total study cohort at 10, 15, and 20 years were 6.0%, 8.6%, and 12.9%, respectively (Figure 3, D), and for death from other causes were 6.0%, 10.8%, and 15.2%, respectively (Figure 3, E).

DISCUSSION

The best choice of conduits in CABG becomes especially apparent when evaluating long-term results. This study reports on the largest patient cohort with 3-vessel disease undergoing total arterial revascularization using exclusively in situ BITA and GEA grafts and among the longest follow-up periods (median, 19.2 years [IQR, 16.2-20.0 years]) to date. Moreover, it is among the few studies that reports on the long-term probabilities of freedom from MACE in total arterial revascularization. Although all-cause death is an important end point in studies investigating the clinical effect of total arterial

TABLE 1. Baseline patient characteristics (N = 201)

Variable	Value
Age (y)	53.2 ± 6.9
Female sex	9 (4.5)
Body mass index >25	45 (22.4)
Medical history	
Previous myocardial infarction	115 (57.2)
Hyperlipidemia	113 (56.2)
Hypertension	85 (42.3)
Diabetes	21 (10.6)
Chronic obstructive pulmonary disease	15 (7.5)
Peripheral vessel disease	11 (5.5)
Smoking history	88 (43.8)
Previous CABG	10 (5.0)
Canadian Cardiovascular Society Angina Grading Scale class	
III	116 (57.7)
IV	45 (22.4)
Left ventricle ejection fraction	
Moderate	50 (24.9)
Poor	13 (6.5)
Left main stenosis	35 (17.4)
Emergency surgery	27 (13.4)

Values are presented as mean ± standard deviation or n (%). CABG, Coronary artery bypass grafting.

revascularization, MACE probabilities may add decisive information in the search of the best choice of conduits in patients with multivessel disease.

The estimated overall survival probability at 20 years after surgery in our patient cohort was 63.5% (95% CI, 55.7%-70.4%). This result confirms the excellent very long-term survival probability reported in the only other study in the literature addressing the 20-year outcomes of CABG with BITA plus GEA grafting. Glineur and colleagues¹⁶ compared patients who received the GEA as a third conduit in addition to BITA grafting with those who received BITA grafting with SVG. They found that the survival probability at 20 years after surgery was 68.9% for BITA/GEA grafting versus 50.3% for BITA/SVG grafting. The 20-year survival benefit of using BITA/SVG compared with SITA/SVG has previously been demonstrated by Lytle and colleagues.¹⁷ They showed that the benefit of BITA grafting increased through the 20 postoperative years and that improved survival compared with SITA grafting became more evident during the second postoperative decade.

There are scarce published data regarding very long-term survival after CABG with at least 2 arterial grafts. We identified only 7 studies reporting on survival probabilities at 15 years or more of follow-up^{6,16-21} (Table 3). As can be deduced from Table 3, the survival benefit of total arterial revascularization compared with BITA/SVG grafting seems to increase with extension of the follow-up period, like the

FIGURE 2. A, Kaplan-Meier curves for overall survival. B, Freedom from major adverse cardiac events (MACE). Shaded areas indicate 95% confidence intervals.

divergence with time of the survival probabilities for BITA/SVG versus SITA/SVG grafting.¹⁷ The graft configuration was not homogeneous in the majority of the reported patient cohorts. In a cohort of 93 patients with BITA/GEA grafting, 20 patients also received an SVG.¹⁶ In another group of patients with total arterial revascularization, the grafts used were not specified.¹⁸ Four studies reported on combined data for patients who underwent BITA grafting with and without SVG.^{6,16,17,21} Studies on more homogeneous patient groups are needed for definite conclusions.

The 20-year estimated freedom from MACE probability in our series was 47.9% (95% CI, 40.1%-55.3%). Only 2 studies included in Table 3 included information on the incidence of MACE in their reports.^{18,21} Garatti and colleagues¹⁸ reported a 15-year freedom from MACE probability of 58% in patients who underwent total arterial revascularization. This is similar to our 15-year probability, although Garatti and colleagues¹⁸ did not include re-CABG

in their composite end point of MACE. Parsa and colleagues²¹ found 35% and 20% event-free survival probabilities (as estimated from the unadjusted Kaplan-Meier curve) for the MACE composite outcome at 15 and 20 years after surgery, respectively, in patients undergoing BITA grafting with or without SVG. These are much worse numbers than those found in both the cohorts with total arterial revascularization. In their analysis, however, patients with multiple ITA grafts were defined only by the number of distal ITA anastomoses. Clinical outcomes of sequential multiple ITA grafting to the same coronary system may resemble those of SITA grafting. Consequently, the beneficial effects of BITA grafting might have been weakened in their study.

The present analysis included in-hospital mortality and MACE. When evaluating the very long-term outcomes of the current technique, it is also worthwhile to reflect on the results after hospitalization, especially on the probabilities of repeat revascularization. In our series,

TABLE 2. Clinical outcomes

Outcome	5 y	10 y	15 y	20 y
Survival probability				
No. at risk	190	166	122	34
Overall survival	94.5 (90.3-96.9)	84.0 (78.1-88.4)	73.9 (67.2-79.5)	63.5 (55.7-70.4)
Cumulative incidence				
No. at risk	176	137	94	25
MACE	12.4 (8.6-17.8)	30.6 (24.7-37.5)	42.1 (35.5-49.3)	52.1 (44.7-59.9)
Myocardial infarction	3.0 (0.6-5.3)	6.5 (3.1-9.9)	7.0 (3.5-10.6)	7.8 (4.0-11.6)
Percutaneous reintervention	1.0 (0.0-2.4)	5.5 (2.3-8.7)	8.6 (4.7-12.5)	9.3 (5.2-13.3)
Reoperation	5.5 (2.3-8.6)	6.5 (3.1-9.9)	7.0 (3.5-10.5)	7.0 (3.5-10.5)
Cardiac death	1.5 (0.0-3.2)	6.0 (2.7-9.4)	8.6 (4.7-12.6)	12.9 (7.6-18.2)
Death from other causes	1.5 (0.0-3.2)	6.0 (2.7-9.3)	10.8 (6.5-15.2)	15.2 (9.8-20.6)

Values are presented as % (95% confidence interval). For the components of MACE, cumulative incidence probabilities were estimated accounting for competing risks. MACE, Major adverse cardiac events.

FIGURE 3. Cumulative incidence curves for the components of major adverse cardiac events. A, Myocardial infarction. B, Percutaneous reintervention. C, Reoperation. D, Cardiac death. E, Death from other causes. Shaded areas indicate 95% confidence intervals.

only 4 patients (2.0%) required postdischarge re-CABG during a follow-up period of up to more than 21 years. Only 27 patients (13.8%) underwent postdischarge PCI.

These extremely low probabilities may be attributed to the superior long-term patency of arterial grafts compared with SVG.²² Furthermore, arterial grafts, being

TABLE 3. Long-term outcomes of coronary artery bypass grafting with at least 2 arterial grafts

Surgical technique	Author(s)	Type of conduits	No. of patients	Survival				Freedom from MACE			
				10 y	15 y	20 y	25 y	10 y	15 y	20 y	25 y
TAR	Suma and colleagues ¹⁹	BITA/GEA	165	85.4 (n = 99)	81.4 (n = 13)	—	—	—	—	—	—
	Glineur and colleagues ¹⁶	BITA/GEA	93	98.9	—	68.9	—	—	—	—	—
	Tavilla and colleagues*	BITA/GEA	201	84 (n = 166)	73.9 (n = 122)	63.5 (n = 34)	—	69.4 (n = 137)	57.9 (n = 94)	47.9 (n = 25)	—
	Shi and colleagues ²⁰	BITA/RA	1037	90 (n = 629)	82 (n = 232)	—	—	—	—	—	—
	Garatti and colleagues ¹⁸	Not specified	209	91	82	—	—	77†	58†	—	—
non-TAR	Lytle and colleagues ¹⁷	BITA/SVG	1152	81 (n = 933)	67 (n = 605)	50 (n = 34)	—	—	—	—	—
	Kurlansky and colleagues ⁶	BITA/SVG	2215	72‡ (n = 1577)	53.5	39‡ (n = 131)	28.6	—	—	—	—
	Glineur and colleagues ¹⁶	BITA/SVG	204	87.2	—	50.3	—	—	—	—	—
	Shi and colleagues ²⁰	BITA/SVG	460	80 (n = 336)	67 (n = 225)	—	—	—	—	—	—
	Parsa and colleagues ²¹	BITA/SVG	728	70‡	50‡	33‡	20‡	55‡ (n = 350)	35‡ (n = 170)	20‡ (n = 80)	15‡ (n = 15)

Values are presented as % (No. at risk). MACE, Major adverse cardiac events; TAR, total arterial revascularization; BITA, bilateral internal thoracic arteries; GEA, right gastroepiploic artery; SVG, saphenous vein graft. *This study. †The composite end point of major adverse cardiac events did not include redo coronary artery bypass grafting. ‡Estimated from the Kaplan-Meier curve.

metabolically active grafts, produce vasoactive and endothelial progenitor substances that may slow the progression of native coronary artery disease.^{23,24} Of 27 patients requiring PCI, the native coronary artery was treated in 25 patients. In these 25 patients, the PCI concerned a vessel of the RCA system (the bypass target of the GEA graft) in 13 patients and the CX and LAD systems (targets of the BITA grafts) in 12 patients. Those numbers suggest that there are no functional differences between the use of the GEA compared with BITA.

The use of the GEA in addition to BITA grafts to achieve total arterial revascularization in 3-vessel disease has the potential advantage of using only in situ grafts. With this technique, 3 different sources supply blood to the myocardium. In contrast, with the BITA Y-graft strategy or the use of the radial artery, the blood supply of the myocardium is dependent on only 1 (1 ITA) or at most 2 sources (an ITA and/or the ascending aorta), respectively. In addition, the use of 3 in situ arterial grafts avoids the need of a Y-anastomosis or a proximal anastomosis on the ascending aorta that may create a potential procedural risk. The patency of the GEA graft is satisfactory. Suma and colleagues¹⁹ reported a patency of 87% in 124 patients with a mean follow-up time of 8.7 years (range, 5-17 years). Suzuki and colleagues²⁵ demonstrated that the long-term patency for the skeletonized GEA is superior to that of the pedicled GEA and reported a cumulative patency

probability for the skeletonized GEA of 90.2% at 8 years after surgery. It should be noted here that to achieve a satisfactory patency and avoid competition of flow, the stenosis in the target vessel for GEA grafting needs to be at least 80%. Other advantages of the GEA are its very low susceptibility to arteriosclerosis,²⁶ its ability to improve flow in response to augmented myocardium demand,²⁷ and its length being long enough to reach any coronary artery.²⁸ Potential disadvantages of the use of the GEA are the increased risk of postoperative ileus and the risk of jeopardizing the graft in case a laparotomy is needed with time.²⁹

In the multivariable Cox regression analysis, age, obesity, smoking history, COPD, and CCSA class IV were the independent adverse predictors of long-term overall survival. Adverse predictors of long-term freedom from MACE were age and CCSA class IV. Studies that examined the influence of obesity, smoking (previous or current), and COPD on both early (in-hospital) and late (after discharge) survival after CABG have shown that all these 3 factors were associated with late, but not with early, mortality.³⁰⁻³² It can be hypothesized that the impaired long-term survival in patients undergoing CABG with obesity, a smoking history, or COPD is a function of their related progressive disorder rather than the CABG surgery in itself. In the present study, diabetes mellitus was not an adverse predictor of long-term survival or MACE. Among

the primary barriers to the widespread use of BITA is the concern about an increased risk of deep sternal wound infection, especially in patients with diabetes.³³ In a systematic review of studies comparing BITA with SITA grafting in patients with diabetes, it was found that this increased risk was limited to patients with a pedicled BITA harvesting approach.³⁴ Patients who underwent skeletonized BITA harvesting had a similar risk of deep sternal wound infection compared with SITA grafting. Notably, in a large population of propensity-score matched patients with diabetes, Dorman and colleagues³⁵ observed improved long-term survival with BITA grafting compared with SITA grafting without any increase in perioperative morbidity or mortality.

Study Limitations

The present study has several limitations. First, this was an observational study without a control group. Therefore, comparisons to BITA grafting supplemented with the radial artery or the SVG as a third conduit could only be undertaken by reviewing the literature. Second, at the time the patient cohort underwent operations, the surgical technique presented in this study was predominantly used in relatively young and healthy patients. This might have influenced the long-term outcomes of the study. Nowadays, the technique is performed also in more high-risk patients. Third, the study included no data on the angiographic quality of the grafts at follow-up. Although it was not the intent of the study to report on graft patency, the findings in patients who required PCI after surgery suggest that there are no functional differences between the use of the GEA compared with BITA.

CONCLUSIONS

According to the results of this study, the exclusive use of in situ BITA and GEA grafts in CABG provides outstanding 15- and 20-year patient survival and freedom from cardiac events in relatively young and healthy patients. Further studies are needed in older patients with more severe comorbidities. Nevertheless, the results from this study and similar studies with sufficient follow-up time suggest that cardiac surgeons should embrace the application of total arterial grafting to further reduce the risks of long-term cardiac events, especially during the second decade after CABG. After Lytle's statement in 1999 that "2 internal thoracic artery grafts are better than 1,"¹ we may nowadays postulate that in 3-vessel coronary artery disease 3 arterial grafts are better than 2.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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