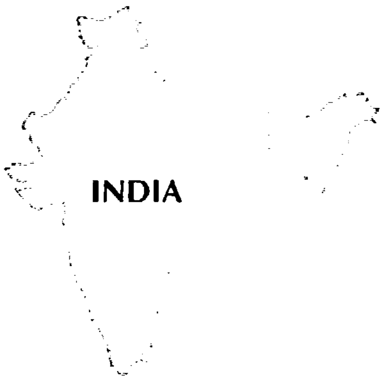

EARLY RESULTS WITH BILATERAL AND SINGLE INTERNAL MAMMARY ARTERY GRAFTS. ARE THEY DIFFERENT?

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ABSTRACT

Between June 1991 and June 1996, 391 patients underwent isolated myocardial revascularization using bilateral internal mammary artery. Three hundred and sixty-five of these patients could be matched retrospectively on the basis of preoperative characteristics with 365 patients operated on during same period who had left internal mammary artery as a single or sequential graft with additional vein grafts. The cardiopulmonary bypass times and aortic cross-clamp times were similar in both groups. There were no statistically significant differences in the two groups in terms of operative mortality (0.55% versus 0.82%), perioperative myocardial infarction (2.46% versus 2.19%), low cardiac output (1.64% versus 1.09%), reexplorations (1.10% versus 1.92%), wound complications (1.10% versus 2.46%), length of stay in the intensive care unit, and total hospital stay. The incidence of respiratory, central nervous system, and renal complications showed no difference between the two groups. Logistic regression analysis showed that the number of internal mammary artery grafts was not a predictor for perioperative complications. If better long-term event-free survival is associated with the use of bilateral internal mammary artery, it should be used wherever possible.

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INTRODUCTION

It is well proven that the internal mammary artery (IMA) is a better conduit for myocardial revascularization than the saphenous vein[1]. However, early results with bilateral internal mammary artery (BIMA) have indicated concerns in terms of chest wound complications, sternal dehiscence, respiratory complications, perioperative instability, and reexplorations[2,3]. Other studies have shown no difference in early mortality and morbidity between the two groups[4]. This study was undertaken to compare early morbidity and mortality in patients having single and bilateral internal mammary artery grafts and to identify predictors of perioperative morbidity and mortality.

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MATERIALS AND METHODS

Between June 1991 and June 1996, 6595 patients with significant coronary artery disease underwent coronary artery bypass grafting at our institute, of whom 391 underwent isolated myocardial revascularization using BIMA. The use of BIMA in our institute has increased in recent years. Using multivariate analysis, 365 of the patients with BIMA grafts could be matched retrospectively with 365 patients who had left internal mammary artery as a single or sequential graft with additional vein grafts during the same period. The operating team was the same for both groups. The patients were matched with regard to age, sex, height, weight, angina, history of heart failure, previous myocardial infarction, hypertension, diabetes mellitus, family history of ischemic heart disease, smoking, lung disease, preoperative electrocardiographic rhythm, left ventricular ejection fraction, and number of coronary arteries bypassed. The medical records in both cohorts were analyzed retrospectively. The decision to use single IMA or BIMA, with or without reversed saphenous vein grafts, depended on the coronary anatomy, age of the patient, presence of diabetes mellitus, obesity, hemodynamic status at the time of surgery, quality of sternum, and flow in the IMA. Patients who were treated by combined procedures, or had single vessel disease, operations on a beating heart, or acute myocardial infarction, were excluded from this study. Significant coronary artery disease requiring bypass grafting was defined in this study as an estimated decrease in cross-sectional area of 75% or more. Diabetes was defined as the need for insulin or oral antidiabetic medication. The criterion for obesity was a Quetelet index (calculated by dividing body weight in kg by the square of the height in meters) of 30 kg/m^2 or greater.

From February 1995 operations were performed using normothermic cardiopulmonary bypass with warm cardioplegic arrest. Before then, operations were carried out with moderate hypothermia (32°C) and cold blood cardioplegic arrest. However, there was no bias in the patient selection in either group during these periods. Hematocrits were maintained at approximately 20%. Operative variables included the number of vessels bypassed, whether endarterectomy was performed, and the number of sequential grafts established. Early mortality was defined as mortality during hospital stay or within 30 days of surgery.

Statistical analyses of categorical variables were carried out using cross-tables with the Pearson chi squared test. If the expected values were small, the Fisher exact test was used. Continuous variables were analyzed with the two-group sample test. In all statistical tests, a p value of less than 0.05 was considered to be significant. Predictors for the binary dependent variables were analyzed using a linear logistic model. Regression analysis was performed with backward elimination and was continued until all nonsignificant predictors were removed.

RESULTS

The preoperative clinical profiles of the two groups are summarized in Table 1. There were no significant differences between the groups with regard to age, sex, height, obesity, cardiac risk factors, preoperative rhythm, left ventricular function, or preoperative intra-

Table 1. **Preoperative Clinical Profiles of Patients Given Single or Bilateral Internal Mammary Artery Grafts**

Variables	Single IMA (n = 365)	Bilateral IMA (n = 365)	p
Mean age ± standard deviation (years)	52.6 ± 6.9	52.6 ± 6.7	0.923
Age range (years)	31 to 70	34 to 71	
Over 60 years	34 (9.32%)	44 (12.05%)	0.231
Over 65 years	18 (4.93%)	9 (2.47%)	0.080
Male	344 (94.25%)	352 (96.44%)	0.160
Mean height ± standard deviation (cm)	166.98 ± 6.48	167.26 ± 5.97	0.669
Mean Quetelet index (kg/m^2)	24.65 ± 3.26	24.44 ± 2.78	0.495
Chronic obstructive or restrictive lung disease	7 (1.92%)	8 (2.19%)	1.000
Angina	296 (81.09%)	296 (81.09%)	1.000
History of heart failure	2 (0.55%)	2 (0.55%)	1.000
Previous myocardial infarction	143 (39.18%)	135 (36.99%)	0.542
Hypertension	152 (41.64%)	133 (36.44%)	0.149
Smoking	104 (28.49%)	97 (26.58%)	0.562
Diabetes mellitus	72 (19.73%)	71 (19.45%)	0.926
Family history of ischemic heart disease	113 (30.96%)	117 (32.05%)	0.750
Preoperative intra-aortic balloon pump	5 (1.37%)	2 (0.55%)	0.451
Left ventricular ejection fraction			
less than 45%	162 (44.38%)	149 (40.82%)	0.369
more than 45%	203 (55.61%)	216 (59.17%)	
Preoperative cardiac rhythm			
normal sinus rhythm	362 (99.18%)	360 (98.63%)	0.725
atrial fibrillation	0	2 (0.55%)	
other	3 (0.82%)	3 (0.82%)	

IMA = internal mammary artery.

aortic balloon pumping. There was no bias in terms of the type of oxygenator or cardioplegia employed. The operative data is shown in Table 2. There were no significant differences in mean cardiopulmonary bypass time, mean aortic cross-clamp time, number of vessels bypassed, or the incidence of endarterectomy or sequential grafts.

The operative outcomes in the two groups are shown in Table 3. There was no significant difference in operative mortality. Two patients in the single IMA group died, one from acute subendocardial infarction and the other from ventricular fibrillation. Of the 3 patients who died in the BIMA group, the cause of death was acute subendocardial infarction in 2 patients and sepsis with multiple organ failure in the other.

Nine patients in the single IMA group and 8 patients in the BIMA group developed perioperative myocardial infarction confirmed by electrocardiogram, blood enzyme levels, and echocardiography. No predictor for perioperative myocardial infarction was found. Six patients in the single IMA group required inotropic support for low cardiac output, 4 of whom needed intra-aortic balloon pumping. In the BIMA group, 4 patients developed low cardiac output needing inotropic support, including intra-aortic balloon pumping in 3 cases. No predictor for low cardiac output was found. A total of 99 patients in the single IMA group and 81 in the BIMA group required inotropic support in the perioperative period; however, the difference was not statistically significant.

There were 4 cases of reexploration in the single IMA group, in one of these a branch of the IMA was bleeding. In the BIMA group there were 7 reexplorations, which were not related to the use of IMA. Twenty-five patients in the single IMA group developed respiratory complications, including 11 who needed extended ventilation and 5 who also had low cardiac output; minitracheostomy was performed in 3 of them to aid bronchial toilet. In the BIMA group, 16 patients needed extended ventilation, 3 of whom had low cardiac output in the early postoperative period; tracheostomy was required in 2 patients and minitracheostomy in one. There was no relationship between preoperative lung disease and postoperative respiratory complications. Linear logistic regression analysis confirmed aortic cross-clamp time to be a predictor for respiratory complications. The number of IMAs used was not a predictor for respiratory complications.

Eight patients in the single IMA group and 7 in the BIMA group had central nervous system complications. All made a complete recovery without any residual neurological deficit. The number of IMAs used was not found to be a predictor for central nervous system complications. There was no serious renal complication in either group. Five patients in the single IMA group and 7 in the BIMA group had a transient rise in blood urea nitrogen and creatinine, which reverted to normal within 5 days.

There was no statistically significant difference in the incidence of infection in the two groups. In the single IMA group, 2 patients had deep wound infections requiring sternal rewiring; diabetes and obesity were present in one of them. There were 6 deep wound infections in the BIMA group, one patient required sternal wire removal, sternal rewiring was required in two, excision of osteomyelitic sternum with omentoplasty was carried out in one case, and two required omentoplasty. Of the patients who developed deep wound infections in this group, 3 had diabetes, 4 were obese, and 1 had a

Table 2. **Operative Data on Patients Given Single or Bilateral Internal Mammary Artery Grafts**

Variables	Single IMA (n = 365)	Bilateral IMA (n = 365)	p
Mean cardiopulmonary bypass time (minutes)	95.9 ± 42.8	93.9 ± 41.4	0.526
Mean aortic cross-clamp time (minutes)	50.3 ± 14.9	51.7 ± 13.0	0.190
Route of cardioplegia			
antegrade	131	132	0.939
antegrade and retrograde	234	233	
Number of vessels bypassed	3.01 ± 0.86	3.12 ± 0.77	0.085
Endarterectomy	15 (4.1%)	12 (3.3%)	0.556
Sequential grafts	17 (4.7%)	23 (6.3%)	0.431
Postoperative intra-aortic balloon pump	4 (1.1%)	6 (1.6%)	0.750
Postoperative rhythm			
normal sinus rhythm	351 (96.16%)	357 (97.81%)	0.279
atrial fibrillation	1	0	
other	13 (3.53%)	8 (2.19%)	
Need for pacing	15 (4.11%)	8 (2.19%)	0.204

IMA = internal mammary artery.

lung infection requiring prolonged ventilation. Superficial wound infection occurred in 2 patients in the single IMA group and in 3 patients in the BIMA group. Linear logistic regression analysis confirmed age above 60 years to be a predictor for wound infection. The number of IMAs used was not found to be a predictor for wound infection. The median period of intensive care, including the recovery room and the coronary care unit, was the same for both groups. The factors responsible for prolonged intensive care included perioperative myocardial infarction, low cardiac output, or prolonged ventilation. There was no significant difference between the median lengths of hospital stay in the two groups. The patients who required prolonged hospital stay were those with wound infections.

DISCUSSION

Hospital mortality in the range of 2.0% to 2.8% for single IMA graft patients and 0.9% to 9.0% for BIMA graft patients have been reported[2,5–9]. The hospital mortality in the two groups in this study were low (0.55% in the single IMA group and 0.82% in the BIMA group) and not significantly different, as also noted by Berreklouw and colleagues[4]. Reported risk factors for early mortality include female sex[5,10,11], as well as small physical size, and small coronary arteries[10]. However, no predictor for operative mortality was found in our study.

The incidence of perioperative myocardial infarction was similar in both groups, which is in accordance with

Table 3. **Clinical Results of Patients Given Single or Bilateral Internal Mammary Artery Grafts**

Variables	Single IMA (n = 365)	Bilateral IMA (n = 365)	p
Hospital mortality	2 (0.55%)	3 (0.82%)	0.654
Perioperative myocardial infarction	9 (2.46%)	8 (2.19%)	0.806
Low cardiac output	6 (1.64%)	4 (1.09%)	0.750
Inotropic support	99 (27.12%)	81 (22.19%)	0.189
Reexploration	4 (1.10%)	7 (1.92%)	0.543
Respiratory system			
unremarkable	340 (93.15%)	342 (93.70%)	0.881
extended ventilation	11 (3.01%)	16 (4.38%)	
hypoxemia with radiological evidence	2 (0.55%)	0	
hypoxemia without radiological evidence	2 (0.55%)	3 (0.82%)	
pneumothorax	5 (1.37%)	3 (0.82%)	
collapse	2 (0.55%)	1 (0.27%)	
consolidation	2 (0.55%)	4 (1.09%)	
tracheostomy	0	2 (0.55%)	
minitracheostomy	5 (1.37%)	1 (0.27%)	
Central nervous system			
unremarkable	357 (97.81%)	358 (98.08%)	0.794
delayed recovery	3 (0.82%)	5 (1.37%)	
excited or irritable on recovery	3 (0.82%)	2 (0.55%)	
psychobehavioral problems	2 (0.55%)	0	
Renal function			
unremarkable	360 (98.63%)	358 (98.08%)	0.579
transient derangement	5 (1.37%)	7 (1.92%)	
Wound complications	4 (1.10%)	9 (2.46%)	0.263
superficial	2 (0.55%)	3 (0.82%)	
deep	2 (0.55%)	6 (1.64%)	
Intensive care stay			
median days (range)	3 (2 to 13)	3 (2 to 14)	0.034
less than 3 days	250 (68.5%)	224 (61.4%)	
more than 3 days	115 (31.5%)	141 (38.6%)	
Hospital stay			
median days (range)	10 (3 to 70)	10 (7 to 62)	0.130
less than 10 days	223 (61.1%)	204 (55.8%)	
more than 10 days	142 (38.9%)	161 (44.2%)	

IMA = internal mammary artery.

other studies[2,8]. Burton and colleagues[12] attributed their higher rate of perioperative myocardial infarction in BIMA graft patients to poor quality vessels, incomplete revascularization, and endarterectomy. An association has been noted between perioperative myocardial infarction and female sex, as well as BIMA graft without vein graft[4]. Jones and colleagues[13] found an increased risk of perioperative myocardial infarction in patients who underwent total arterial revascularization with BIMA, which they attributed to a discrepancy between IMA flow and myocardial demand. Suma and colleagues[14] found a two-fold increase in the incidence of perioperative myocardial infarction in patients with a small body surface area, although this was not statistically significant. In the present study, no predictors for perioperative myocardial were found. However, an association between low cardiac output and perioperative myocardial infarction has been reported[4].

The incidence of low cardiac output was similar in both groups in this study. Kouchoukos and colleagues[2] also found no difference in the frequency of inotropic support for low cardiac output in both groups. Although Lytle and colleagues[3] noted more reexplorations in BIMA graft patients, the incidence of reexploration in the present study was low and comparable in both groups, as reported in other studies[7,15]. We also found no difference in the frequency of respiratory complications in the two groups, as noted by others[4,8]. Nor was there a correlation between postoperative respiratory complications and significant preoperative lung disease or the number of IMAs used. Aortic cross-clamp time was found to be a predictor for respiratory complications.

The prevalence of wound complications in BIMA graft patients has been reported to range from 1.5% to 8.5%[8,16]. More wound infections were reported in earlier studies, which may be attributed to less experience with the technique[2]. The low incidence of wound infections in the present study is similar to that reported by Galbut and colleagues[8]. They attributed low infection rates in both groups to their technique using skeletonized IMA independent of the endothoracic fascia, internal mammary veins and lymphatics, and found diabetes mellitus, advanced age, obesity, and prolonged mechanical ventilation to be a risk factor in both patient groups. Diabetes was also found to be a predictor of wound infection by other authors[2,7]. Kouchoukos and colleagues[2] found significant differences in the incidence of sternal infection (1.9% in single IMA versus 6.9% in BIMA graft patients), superficial chest wound infections, and sterile dehiscence or delayed healing (2.9% in single IMA versus 10.2% in BIMA graft patients). They noted a Quetelet index of 30 kg/m^2 or greater predisposed to wound infections. Cosgrove and colleagues[7] also found significantly more wound complications with the use of BIMA (2.4%) compared with single IMA (0.3%), and noted diabetes mellitus and advanced age as risk factors for wound complications. In the present study, no relationship was found between diabetes, obesity, or prolonged mechanical ventilation and wound infection. However, age above 60 years was found to be a strong predictor for wound infection. Advanced age was also noted to be a risk factor for wound infections in other studies[7,8]. The number of IMAs used was not a predictor for wound complications.

Age above 60 years, blood cardioplegia, higher left ventricular end-diastolic pressure, and low cardiac output have been reported as important predictors of prolonged intensive care stay, and wound infection as a major factor in prolonged hospital stay[4]. We found perioperative myocardial infarction, low cardiac output, and prolonged ventilation to be the most important factors in prolonging intensive care. Patients with wound infections tended to have prolonged hospital stay. During the later period of this study, we noted that the hospital stay decreased to a median of 7 days in both groups, reflecting a decrease in the number of complications. Since the linear logistic regression analysis was performed with a very small number of incidents, it should be interpreted as indicative.

We could not demonstrate any statistically significant differences in the hospital mortality or morbidity between the use of one or two IMAs. Nor was the use of one or two IMAs found to be a predictor of hospital complications. From the first use of IMA for coronary bypass grafting by Green and colleagues[17] in 1968, and later by Barner's group[6], the superiority of IMA over saphenous vein has been firmly established. Its capability of size adaptation to provide sufficient blood flow to meet the demands of the myocardium, prolonged patency, resistance to atherosclerosis and to the development of intimal hyperplasia, make it a better conduit than saphenous vein[18]. Superior patency, greater freedom from ischemic events, and less need for interventional therapy such as percutaneous transluminal angioplasty and redo coronary artery bypass grafting are attainable with the use of IMA[6,9]. Therefore, its use should not be withheld. In view of the comparable low operative risks in patients receiving either single or double IMA grafts, we recommend the use of both IMAs whenever possible, to provide maximum benefit to the patient.

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Appendix 1. **Variables Considered as Independent Variables in Linear Logistic Regression Analysis**

Preoperative Clinical Variables	Operation-Related Variables	Postoperative Variables
Age all years	Number of vessels bypassed	Perioperative myocardial infarction*
Age ≥ 60 years	Endarterectomy	Low cardiac output*†
Age ≥ 65 years	Route of cardioplegia	Lung complications*†
Sex	Sequential grafts	Wound complications*†
Weight	Use of intra-aortic balloon pump	Central nervous system complications*†
Height	Left ventricular ejection fraction (%)	Renal complications*†
Angina	Total cardiopulmonary bypass time	
History of heart failure	Aortic cross-clamp time	
Previous myocardial infarction	Type of cardioplegia	
Smoking	Preoperative rhythm	
Hypertension	Postoperative rhythm	
Diabetes mellitus	Need for pacing	
Chronic obstructive lung disease	Support in weaning from cardiopulmonary	
Family history of ischemic heart disease	bypass	

*Not used to analyze perioperative infarction.
†Not used to analyze low cardiac output.

Appendix 2. **Predictors for Complications in Patients Given Single or Bilateral Internal Mammary Artery Grafts**

Respiratory System Complications in 48 Patients (6.6%)					
Predictor	*Beta Estimate*	*Standard Error*	*p*	*Odds Ratio*	*Confidence Limits (95%)*
Aortic cross-clamp time	0.0256	0.0104	0.0139	1.026	1.00 to 1.05
Single or bilateral IMA	0.1848	0.3039	0.5432*		
Central Nervous System Complications in 15 Patients (2.0%)					
Predictor	*Beta Estimate*	*Standard Error*	*p*	*Odds Ratio*	*Confidence Limits (95%)*
Age	0.1211	0.0426	0.0045	1.129	1.04 to 1.22
Single or bilateral IMA	0.1133	0.5432	0.8348*		
Wound Infections in 13 Patients (1.8%)					
Predictor	*Beta Estimate*	*Standard Error*	*p*	*Odds Ratio*	*Confidence Limits (95%)*
Age ≥ 60 years	1.4324	0.6266	0.0223	4.1885	1.22 to 14.30
Single or bilateral IMA	0.4924	0.6244	0.4303*		

IMA = internal mammary artery.

*Not significant