Long-term Results of Coronary Artery Bypass Surgery in Patients With Severely Depressed Left Ventricular Function*

Itzhak Shapira, MD, FCCP; Aharon Isakov, MD, Vladimir Yakirevich, MD, and Marcel Topilsky, MD, FCCP

Study objective: The objective of the present study was to evaluate medium- and long-term results of coronary artery bypass grafting (CABG) in patients with severe left ventricular dysfunction (LVD).

Design: Prospective evaluation (clinical follow-up and equilibrium radionuclide angiography scan) of all the patients with severe LVD who underwent CABG from November 1986 to November 1991 at the Tel Aviv Medical Center and were referred to the Post Cardiac Surgery Follow-up Clinic at this institution.

Patients: Seventy-four consecutive patients (65 men, 9 women, aged 43 to 82 years; mean age, 68.2 years) with left ventricular ejection fraction (LVEF) of 30% or less who underwent isolated CABG (without automatic implantable cardioverter-defibrillator implantation, aneurysmectomy, valve replacement, or other open heart procedures) during a 5-year period and were discharged from hospitalization were prospectively evaluated. Preoperatively, 62% of patients had angina, 65% had congestive heart failure (CHF), and the LVEF ranged from 10 to 30%. The mean number of grafts was 2.98 per patient; the internal mammary artery (IMA) was used in 54 patients. The patients were followed up to 96 months (mean, 64.9 months) post-surgery for survival, clinical status, and left ventricular function.

Results: Survival was 96%, 93.2%, 91.9%, 87.8%, 86.5%, 83.8%, and 83.8%, at 1, 2, 3, 4, 5, 6, and 7 years, respectively. Postoperatively, mean angina class improved from 2.9 to 1.4 (p<0.0001) and mean CHF class improved from 2.7 to 1.8 (p<0.0001). Mean LVEF improved from 23.5% preoperatively to 35.7% postoperatively (p<0.0001).

Conclusions: The following occur in patients with coronary artery disease and severe LVD undergoing CABG: (1) good medium- and long-term survival is attained; (2) angina class improves; (3) CHF class improves; (4) LVEF objectively improves; and (5). IMA can be used safely as a conduit.

(CHEST 1995; 108:1546-50)

Key words: coronary artery bypass surgery; coronary artery disease; elderly; equilibrium radionuclide angiography scan

In patients with advanced left ventricular dysfunction (LVD), medical therapy carries a poor long-term prognosis. This condition is currently the most common indication for cardiac transplantation; however, the waiting list is long, especially in countries where, owing to religious rules, the number of organs is very limited, older patients or those with coexistent diseases are excluded.

Although these limitations appear to make coronary artery bypass grafting (CABG) an attractive therapeutic approach in patients with LVD, this treatment has only recently become an accepted alternative for such patients. CABG in these patients carries an increased surgical risk, and angina relief may be disappointing, and the graft patency might be compromised because of inadequate runoff in the area of the extensive scar.

The multicenter trials of CABG have been confined to patients with relatively preserved left ventricular function. Although some studies evaluated the results of CABG in patients with LVD, eg, left ventricular ejection fraction (LVEF) less than 30, the number of the studied patients was limited.

A large study on the results of CABG in patients with LVD did not report the long-term results of the procedure. Another limitation of most of these studies is the inclusion of patients with additional interventions, like placement of automatic implantable cardioverter-defibrillator, valve replacement, and aneurysmectomy, where clearly the pathophysiologic condition and mechanism of surgical benefits are different in these patients. In some prior reports, the long-term evaluation included only survival but not the symptomatic state and left ventricular function.

In the present study, the long-term results of CABG in patients with LVD, eg, LVEF of 30% or less and treated at the Post Cardiac Surgery Clinic of Tel Aviv Medical Center were prospectively analyzed. Preop
operative status, the type of surgery, survival, change in symptoms, and left ventricular performance before and after revascularization were reviewed to determine whether this population of patients benefited from CABG.

**Methods**

Study Patients

A prospective analysis was undertaken of all 74 consecutive patients in whom preoperative LVEF was equal to or less than 30%, underwent isolated CABG between November 1986 and November 1991, and were treated at the Post Cardiac Surgery Follow-up Clinic of our institution. Patients who underwent concomitant left ventricular aneurysmectomy, valve replacement, an arrhythmia operation, or placement of automatic implantable cardioverter-defibrillator or other open heart procedures were excluded from the study. This study does not include patients within the same time period who would have qualified for this evaluation but died from intraoperative events or during the first 2 months postoperatively.

Sixty-five patients (88%) were men. Ages ranged from 43 to 82 years (mean, 68.2 years). Indications for surgery were as follows: 46 patients (62%) complained of angina and 48 patients (65%) had congestive heart failure (CHF); in 12 (16%) it was manifested as episodes of pulmonary edema. Prior myocardial infarction was documented in 65 (85%) of the study population.

The preoperative LVEF of the left ventricle was determined by contrast angiography in all of the patients and by equilibrium radionuclide angiography in 48. The lowest LVEF was 10% and the highest 30%; the mean LVEF was 23.5%. Sixteen patients (22%) had LVEF between 10 and 20% and 58 patients (78%) had LVEF between 21 and 30%. To normalize preoperative contrast angiographic LVEF to equilibrium radionuclide angiography scan equivalents, a regression equation was used: equilibrium radionuclide angiography LVEF = 0.86 X ventriculographic LVEF + 2.9.

In the present study, the formula changes the absolute value of the ejection fraction between the two methods by 1.9% or less.

Surgery

Surgery was performed electively in 72% of the patients and urgently in 21 patients (11 of them came from the cardiac ICU). Intra-aortic balloon pump was used in eight patients. All patients underwent CABG using a standard operative technique. Single cannulation of the right atrium was carried out with a two-stage venous cannula. Myocardial preservation was performed by systemic hypothermia, topical hypothermia, and cold cardioplegic solution administered into ascending aorta before each graft. The number of grafts each patient received was determined by the senior surgeon at the time of the surgery and most patients underwent complete revascularization. Three patients (4%) had a single coronary artery bypass graft, 14 (19%) had two grafts, 43 (58%) had three grafts, 10 (14%) had four grafts, 3 (4%) had five grafts, and 1 (1%) had six grafts. The mean number of grafts per patient was 2.99. Fifty-four patients (73%) had a left internal mammary artery (IMA) graft placed to the left anterior descending artery and 13 (18%) had a right IMA graft placed to the right coronary artery. The operative death rate during this period of the study was 3.6% for all procedures.

Follow-up

Follow-up was carried out in all patients during their visits to the Follow-up Clinic (starting 2 months after the surgery): during the first year after the surgery, four times yearly; during the next 2 years, three times yearly; and once a year afterwards. Patients were followed-up until 8 years following surgery, November 1994, or until death, whichever of the three occurred first. Each patient underwent an equilibrium radionuclide angiography scan 5 to 7 months (mean, 5.8 months) after CABG as a part of the routine follow-up in this clinic. Preoperative and postoperative angina and CHF were evaluated by the physicians running the Post Cardiac Surgery Follow-up Clinic (I.S. and A.L.) and rated according to the Canadian Cardiovascular Society and New York Heart Association criteria, accordingly. When death occurred, its cause was recorded on the death certificate.

Statistical Analysis

Survival curves were drawn on an actuarial basis using the Kaplan-Meier technique and were compared by the Wilcoxon test.
The statistical significance of differences was determined using the Wilcoxon signed-rank test for ordinal data (comparison of postoperative and preoperative symptomatic status, angina, and CHF) and paired t test (comparison of postoperative and preoperative LVEF).

**RESULTS**

**Survival**

The follow-up period ranged from 4 to 96 months (mean, 64.9 months) after CABG. During this period, 12 patients died at 4, 7, 11, 13, 15, 26, 37, 41, 46, 57, 64, and 71 months, respectively. The causes of death were cardiac (seven patients) and noncardiac (five patients died of cerebrovascular accident, cancer, and renal failure). The overall survival rates and cardiac survival are tabulated in Figure 1. Five patients of the higher LVEF (21 to 30%) subgroup died 11, 13, 41, 64, 71 months after CABG, respectively, all of them of noncardiac causes.

**Symptoms**

Figure 1 shows the changes in angina symptoms. Patients with marked angina had significant improvement, most of the patients being in low angina class during the follow-up period. The mean angina class among all patients improved from 2.9 preoperatively to 1.4 postoperatively (p<0.0001). The anginal class before surgery was I in 18 patients, II in 6, III in 17, and IV in 33 patients. Following surgery, anginal class was I in 44 (17 from class I, 4 from class II, 14 from class III, and 9 from class IV), II in 25 (1 from class I, 2 from class II, 2 from class III, and 23 from class IV), III in 1 (unchanged), and IV in 1 patient (unchanged) (Fig 2). The mean CHF class among the patient population improved as well (Fig 3), from 2.7 preoperatively to 1.8 postoperatively (p<0.0001). The CHF class before surgery was I in 12 patients, II in 18, III in 24, and IV in 20 patients. Following surgery, CHF class was I in 32 patients (9 from class I, 12 from class II, and 11 from class III), II in 30 (3 from class I, 4 from class II, 12 from class III, and 11 from class IV), III in 10 (2 from class II, 1 from class III, and 7 from class IV), and IV in 2 patients (unchanged).

**Left Ventricular Function**

Mean LVEF increased significantly (p<0.0001) postoperatively, from 23.5 to 35.7%. The changes in this parameter are shown in Figure 4. The largest increase in LVEF was 28%. In only 4 patients (5%) did the ejection fraction decrease significantly (LVEF >7%); in 54 patients (73%), LVEF increased by more than 7%.

---

**Figure 3.** Changes in CHF status (by New York Heart Association) as result of CABG, before and after surgery, respectively.

**Figure 4.** Changes in LVEF as result of CABG, before and after surgery, respectively.
DISCUSSION

Short-term results of CABG in patients with depressed left ventricular function were reviewed in a significant number of studies\(^2-20\) and this was beyond the scope of the present study. In the last decade, however, only three studies were published\(^1,5,14\) containing relatively large number of patients and concerning long-term results. The present study prospectively evaluates postoperative long-term survival and changes in symptoms and left ventricular function in a population of patients with LVD who underwent CABG. In addition, this study specifically excluded those patients who underwent combined procedures.

**Survival**

The survival for the presently studied population is 96% at 1 year, 93.2% at 2 years, 91.9% at 3 years, 87.8% at 4 years, 86.5% at 5 years, 83.8% at 6 years, and 83.8% at 7 years. These results are similar to those reported by Milano et al\(^8\) in patients with severely depressed left ventricular function and to those obtained in patients with moderately depressed LVEF\(^10,19-22\) and better than those described in studies reviewing the late outcome of CABG in patients with severely depressed LVEF\(^3,11-13\). The prognosis of patients with severe LVD, medically treated, was reported in a number of studies.\(^2,6-9,18,20\) In these studies, the short-term (1 year) mortality was 10 to 50%, and the late mortality, at 2 and 5 years, was 38% and 96%, respectively. When medically treated groups (patients who refused operation or were not considered for surgery) were compared with surgically treated groups, the late survival was improved in the surgical groups. The most recent study was performed in 1981,\(^5\) and surgical techniques have improved since. Recent studies demonstrated a continuous improvement in operative mortality,\(^5\) in patients in stable condition with severe LVD, CABG may be even safer than is reflected in the overall statistics.\(^4\)

**Symptoms**

The improvement in symptoms, as defined by changes in angina and CHF parameters, was significant. Ninety-seven percent of the patients were in angina class I and II, and 84% were in CHF class I and II as a result of the surgery. We agree with Elefteriades et al\(^4\) that CABG should be performed in patients with severely depressed left ventricular function, as previously recommended by others\(^17,20,23\) even in the absence of anginal syndrome or in the presence of CHF. Once the patients are discharged from hospital, the long-term survival is similar to patients with moderately depressed left ventricular function and there is a significant improvement in anginal status and CHF.

**Left Ventricular Function**

This parameter as determined by LVEF was shown to improve after CABG in patients with severe LVD. The improvement of left ventricular function, as shown by others as well,\(^4,5\) is of clinical relevance. The possible explanation for this observation is that function was restored by provision of blood flow to previously dysfunctional regions of ischemic or hibernating myocardium.\(^4\)

**IMA Graft**

IMA was used whenever technically possible. Poor left ventricular function was considered a contraindication for use of IMA.\(^3,24\) compared with a saphenous vein graft, this conduit may not provide as much early flow and may be more susceptible to spasm. In this study, however, no problems regarding to this use were apparent. We, as others,\(^24\) suggest that it is possible that the known long-term patency advantages of IMA graft may contribute to the excellent results in patients with depressed left ventricular function. Therefore, we recommend the use of the IMA in such patients.

**Limitations of the Study**

The present study is based on a selected population: patients with coronary artery disease and severe LVD who were referred for surgery and survived 2 months postoperatively. It does not compare their outcome with the outcome of a similar cohort of patients who were not offered surgery and therefore it cannot provide guidance to practitioners in selecting such patients for bypass surgery or for medical treatment. Another limitation of the study is that neither thallium imaging nor positron emission tomography was performed preoperatively to distinguish reversible ischemia and therefore viable myocardium from irreversible scattered and nonviable myocardium. Such studies, which should be employed preoperatively in our era, could further enhance selection of patients for CABG in the setting of severely depressed left ventricular function.\(^4\) Finally, the equilibrium radionuclide angiography scans, although performed according to an identical protocol, were done in three different laboratories. The results of the tests, however, were blindly interpreted by experienced physicians.

**Clinical Implications**

CABG may be offered to patients with severely depressed left ventricular function. For a great majority of such patients, CABG is probably the most accurate treatment. Randomized trials comparing medical therapy with CABG for such patients should confirm this. In patients with coronary artery disease and severe LVD, the long-term survival is excellent and improvement of quality of life and left ventricular function is to be expected. The use of IMA conduit is recommended for this group of patients.
ACKNOWLEDGMENTS: We wish to thank Esther Lior for secretarial assistance in running the Clinic and for research support and Yael Villa, MSc, for statistical evaluation of the data presented in this study.

REFERENCES