ORIGINAL ARTICLE

Coronary Artery Bypass Grafting in Patients with Left Ventricular Dysfunction

Fei-Yi Wu[1], Yen-Chou Lu[2], Shiau-Ting Lai[1], Zen-Chung Weng[1], Cheng-Hsiung Huang[1]*

[1]*Division of Cardiovascular Surgery, Department of Surgery, National Yang-Ming University School of Medicine, and Taipei Veterans General Hospital, and* [2]*Division of Cardiovascular Surgery, Department of Surgery, Tzu Chi University School of Medicine, and Buddhist Taipei Tzu Chi General Hospital, Taiwan, R.O.C.*

Background: Coronary artery bypass grafting surgery (CABG) remains a challenge for patients with coronary artery disease and left ventricular (LV) dysfunction. The aim of this study was to evaluate the result of CABG in patients with LV dysfunction.

Methods: Medical records of 1,847 patients who underwent primary, isolated CABG at Taipei Veterans General Hospital from January 1, 1991 to December 31, 2002, were reviewed. The mortality rate associated with clinical and operative variables was compared between patients with LV ejection fraction (LVEF) ≥ 35% and patients with LVEF < 35%.

Results: Patients with LVEF < 35% had more episodes of myocardial infarction (57.5% *vs* 28.9%, $p < 0.001$) and history of congestive heart failure (18.1% *vs* 3.2%, $p < 0.001$), higher New York Heart Association (NYHA) class, and higher angina class. Longer cardiopulmonary bypass time (147 ± 44 minutes *vs* 137 ± 40 minutes, $p <$ 0 .001) but fewer left internal mammary artery (LIMA) grafts (46.8% *vs* 65.7%, $p < 0.001$) were used in patients with LVEF < 35%. Patients with LVEF < 35% had significantly higher hospital mortality (6.6% *vs* 2.2%, $p < 0.001$), higher major morbidity (23.3% *vs* 16.1%, $p < 0.01$), and longer hospital stay (25 ± 23 days *vs* 21 ± 16 days, $p < 0.01$).

Conclusion: Although patients with LV dysfunction had higher mortality and morbidity, CABG could be done in these high-risk patients with acceptable results. [*J Chin Med Assoc* 2006;69(5):218–223]

Key Words: coronary artery bypass grafting, hospital mortality, left ventricular dysfunction

Introduction

The increasing incidence of heart failure has created a greater number of patients with left ventricular (LV) dysfunction who undergo coronary artery bypass grafting (CABG) surgery.[1,2] Compared with continued medical treatment, CABG is reported to give better long-term survival expectancies in this group of patients.[3–5] However, LV dysfunction is reported to be the predictor of mortality in CABG. Surgical revascularization has been shown to carry a high perioperative mortality and morbidity in patients with LV dysfunction.[3,6,7] On the other hand, with recent improvements in anesthesia, surgical technique, myocardial protection, and perioperative support, CABG could be done in these patients with acceptable safety.[8–11] It could also be an alternative for heart transplantation for these high-risk patients.[8,12,13]

Because of economic development and change in lifestyle, coronary artery disease has become one of the leading causes of mortality in Taiwan. We have previously reported our experiences with the outcome of CABG,[14,15] but the portion of experiences in patients with LV dysfunction remains unknown. The purpose of this study was to evaluate the results of CABG in these high-risk patients. In this study, we hope to provide information about indication of CABG in patients with LV dysfunction and improve the quality of patient care.

*Correspondence to: Dr. Cheng-Hsiung Huang, Division of Cardiovascular Surgery, Taipei Veterans General Hospital, 201, Section 2, Shih-Pai Road, Taipei 112, Taiwan, R.O.C.
E-mail: chhuang@vghtpe.gov.tw • Received: October 17, 2005 • Accepted: January 17, 2006

Methods

A total of 3,308 patients underwent CABG surgery in Taipei Veterans General Hospital from January 1, 1991 to December 31, 2002. Seventy of the patients underwent repeat CABG. In addition to CABG, associated procedures were done in 401 patients, including repair of LV aneurysm, mitral valve repair, mitral valve replacement, aortic valve replacement, repair of ventricular septum rupture after myocardial infarction (MI), carotid endarterectomy, repair of abdominal aortic aneurysm, repair of ascending or descending thoracic aortic aneurysm, bypass surgery for peripheral arterial occlusive disease, and resection of myxoma. Excluding patients with repeat CABG and associated procedures, 2,842 patients had primary, isolated CABG during the 12-year study period.

The LV function was evaluated by LV ejection fraction (LVEF), which was determined by multigated equilibrium radionuclide angiography. The medical records of 1,847, among 2,842 patients who had preoperative LVEF examinations, were reviewed retrospectively. Eighteen variables (Table 1) and 7 operative variables (Table 2) were analyzed and compared between patients with LVEF < 35% and patients with LVEF ≥ 35%. The severity of angina was graded from 1 to 4 as defined by the Canadian Cardiovascular Society.[16] The severity of symptoms of congestive heart failure was categorized into 1 of 4 levels, depending on exercise limitations according to New York Heart Association (NYHA) function classification. Smoking 1 pack or more of cigarettes per day up to the time of surgery was considered a contributing factor for congestive heart failure.

Table 1. Clinical variables of patients with or without LVEF < 35%

	LVEF < 35%	Percentage (%)	LVEF ≥ 35%	Percentage (%)	p
Number	365	19.8	1,482	80.2	
Age	38–86		39–86		
Mean	67.9 ± 7.4		67.5 ± 7.9		0.362
Sex					0.677
Male	336	92.1	1,352	91.2	
Female	29	7.9	130	8.8	
Angina class					0.000
Class 1	51	14.0	148	10.0	
Class 2	166	45.5	851	57.4	
Class 3	123	33.7	442	29.8	
Class 4	25	6.8	41	2.8	
NYHA class					0.000
Class 1	154	42.2	983	66.3	
Class 2	105	28.8	401	27.1	
Class 3	61	16.7	72	4.9	
Class 4	45	12.3	26	1.8	
Smoking	173	47.4	733	49.5	0.484
Hypertension	228	62.5	1,015	68.5	0.029
Diabetes	142	38.9	486	32.8	0.031
Cholesterol > 250 mg/dL	101	27.7	497	33.5	0.034
History of MI	210	57.5	428	28.9	0.000
History of CHF	66	18.1	48	3.2	0.000
Creatinine > 2.0 mg/dL	48	13.2	120	8.1	0.004
COPD	26	7.1	71	4.8	0.088
History of CVA	31	8.5	112	7.6	0.584
PAOD	39	10.7	102	6.9	0.020
LV aneurysm	22	6.0	15	1.0	0.000
History of PTCA	64	17.5	273	18.4	0.762
LVEF					
Mean	27 ± 5.0		50.5 ± 8.7		0.000

CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; LVEF = left ventricular ejection fraction; MI = myocardial infarction; PAOD = peripheral arterial occlusive disease; PTCA = percutaneous transluminal coronary angioplasty.

Table 2. Operative variables of patients with or without LVEF < 35%

	LVEF < 35%	Percentage (%)	LVEF ≥ 35%	Percentage (%)	*p*
Emergent operation	24	6.6	86	5.8	0.621
LMCA lesion	63	17.3	315	21.3	0.096
Diseased vessel number					0.055
Single	14	3.8	89	6.0	
Double	58	15.9	289	19.5	
Triple	293	80.3	1,104	74.5	
Anastomosis number	3.4 ± 1.0		3.3 ± 1.1		0.006
Ischemic time (min)	87 ± 735		86 ± 733		0.694
CPB time (min)	147 ± 44		137 ± 40		0.000
LIMA graft	171	46.8	974	65.7	0.000

CPB = cardiopulmonary bypass; LIMA = left internal mammary artery; LMCA = left main coronary artery; LVEF = left ventricular ejection fraction.

Hypertension was considered a condition requiring antihypertensives. Clinical diabetes mellitus was considered a condition requiring insulin or oral antidiabetics.[17] A history of MI was recorded if the patient had been informed by a physician of a definite infarction or if the patient's electrocardiogram revealed an old infarction prior to surgery. Peripheral arterial occlusive disease was documented by a combination of ischemic symptoms and diminished pulses in the lower limb, or by history of a previous construction procedure for peripheral arterial occlusive disease.[17]

Operative variables included priority of procedures, presence or absence of the left main coronary artery lesion, number of coronary arteries involved, number of anastomoses, cardiopulmonary bypass time, aortic cross-clamping time, and use of arterial grafts (Table 2). Definition of the operation as elective or emergent was determined by the operating surgeons, but emergent procedures generally included those performed less than 24 hours after coronary angiography or during a clearly deteriorating clinical condition.[18] The left main lesion was considered present when the extent of luminal narrowing of the left main coronary artery was 50% or greater. The number of seriously stenosed coronary arteries was defined according to the number of coronary arteries with luminal narrowing of 70% or more.[19]

The surgical techniques have been described in previous reports.[14,15] All operations used cardiopulmonary bypass with moderate hemodilution (hematocrit, 20–25%) and moderate systemic hypothermia (25–28°C). Ascending aortic and 2-stage, single-venous cannulation was employed. Myocardial preservation was generally achieved with intermittent, multidose, cold-crystalloid cardioplegia. Crystalloid cardioplegia was infused through the aortic root at least every 20 minutes, and was then additionally infused into each completed vein graft. Blood cardioplegia was usually used for patients with LV hypertrophy, cardiogenic shock, or acutely occluded coronary arteries. Distal coronary anastomoses were performed first in the arrested heart with aortic root venting. Aortic anastomoses were done over a partial clamp in the beating, nonloading heart.

Statistical analysis

All data were expressed as means ± standard deviation or percentages where appropriate. Discrete variables were analyzed with Chi-square test, and continuous variables were analyzed by unpaired Student's *t* test. A p value less than 0.05 was considered statistically significant.

Results

From January 1, 1991 to December 31, 2002, 1,847 patients underwent primary isolated CABG. A total of 365 patients (19.8%) had LVEF < 35%, while 1,482 patients (80.2%) had LVEF ≥ 35% (Table 1). There was no significant difference in the mean age or sex distribution. The prevalence of smoking as a risk factor also showed no significance. The comorbidity of chronic obstructive pulmonary disease and history of cerebrovascular accident were also the same between both groups. Angina and NYHA class were significantly more severe in LV dysfunction patients. These patients also had a significantly higher percentage of diabetes, and history of MI, congestive heart failure, peripheral arterial occlusive disease and LV aneurysm. Patients with LVEF ≥ 35% had a significantly higher percentage of hypertension and cholesterol levels greater than 250 mg/dL. There was no significant difference in the history of percutaneous transluminal coronary angioplasty between the 2 groups (Table 1).

There was no significant difference in the percentage of emergent operation, left main coronary artery lesion, number of stenotic coronary artery vessels, and aortic cross-clamp time between the 2 groups (Table 2). However, patients with LVEF < 35% had significantly more grafts, anastomoses, and longer cardiopulmonary bypass times. Significantly more left internal mammary artery (LIMA) grafts were used in patients with LVEF ≥ 35% (Table 2).

Patients with LVEF < 35% had significantly higher operative and hospital mortality (Table 3). A significantly higher incidence of major morbidity was also noted in patients with LV dysfunction. Patients with LVEF < 35% had significantly longer hospital stays.

Discussion

LV dysfunction has been identified as one of the most significant independent predictors of operative mortality.[20,21] Christakis et al[9] reported a higher operative mortality rate (9.8%) for patients with LVEF < 20% than those with LVEF between 20 and 40% (4.8%) and those with LVEF > 40% (2.3%). Because of widespread application of thrombolysis and the increase in survivors from acute MI, the prevalence of moderate-to-severe LV dysfunction seemed to increase in patients referred for CABG. Endovascular therapy might also delay surgical revascularization until coronary atherosclerosis is more extensive and ventricular dysfunction is more severe.[22]

Although mortality has shown to be high for LV dysfunction patients undergoing CABG, Cimochowski et al[18] advocated that a combination of chemical, metabolic, and mechanical support could reduce the operative mortality rate to 1.8% in patients with severe LV dysfunction who underwent isolated coronary artery bypass grafting. Mickleborough et al[10,23] also reported lower mortality and morbidity for patients with poor LV function (LVEF < 20%) by improved cardioplegic techniques.

Better results have been found with surgical treatment than medical treatment in patients with LV dysfunction. Alderman et al[3] compared medical and surgical treatments in poor LV function patients (LVEF < 35%). The 5-year survival rate was 63% in surgically treated patients, compared with 43% in medically treated patients. Although the operative mortality was 6.9%, the authors concluded that patients with predominantly ischemic pain symptoms, despite poor LV function, benefit from surgery.

Table 3. Results of CABG surgery in patients with or without LVEF < 35%

Outcome	LVEF < 35%	Percentage (%)	LVEF ≥ 35%	Percentage (%)	*p*
Operative mortality (< 30 days)	13	3.6	18	1.2	0.005
Hospital mortality	24	6.6	33	2.2	0.000
Major morbidity	85	23.3	238	16.1	0.002
Lower limb wound infection	20	5.5	76	5.1	
Postoperative heart failure	12	3.3	12	0.8	
Respiratory failure	11	3.0	25	1.7	
Postoperative VT	10	2.7	28	1.9	
Perioperative MI	6	1.6	20	1.3	
Stroke	6	1.6	17	1.1	
Renal failure	6	1.6	16	1.1	
Mediastinitis	5	1.4	13	0.9	
GI bleeding	4	1.1	12	0.8	
Sternal dehiscence	3	0.8	11	0.7	
Go-in for bleeding	3	0.8	16	1.1	
UTI	2	0.5	6	0.4	
Phrenic nerve palsy	0	0.0	3	0.2	
Hospital stay (days)	25 ± 23		21 ± 16		0.001

CABG = coronary artery bypass grafting; GI = gastro-intestinal; MI = myocardial infarction; UTI = urinary tract infection; VT = ventricular tachycardia.

In the current study, patients with LV dysfunction were found to have a higher degree of angina and NYHA class, significantly higher percentage of diabetes, and history of MI, congestive heart failure, peripheral arterial occlusive disease, and LV aneurysm (Table 1). Christakis et al[9] reported that patients with LV dysfunction were older, predominantly male, had a higher percentage of left main stenosis, and more frequently required urgent surgery for unstable angina. Yau et al[22] demonstrated a decrease in mortality with time, despite an increasing prevalence and risk-profile of patients with LV dysfunction.

In addition to LIMA being a patent and long-lasting graft, it is also reported to have considerably reduced mortality.[24] Anderson et al[25] demonstrated an obvious enhancement of late survival with the use of IMA grafting in patients with chronic congestive heart failure over a 5-year follow-up period. However, other reports denied its influence on the long-term survival in patients with LV dysfunction.[20,26] Because of the conflicting results, LIMA grafting was not used routinely in the poor LV function group in the current study.

There were several limitations in the present study. The data for some variables were not available for all patients because of the study's retrospective nature. Only 1,847 patients (65%) had preoperative LVEF examination. The LVEF study was not universal even for patients of emergent CABG, which may have affected our mortality rate in those high-risk patients. The study period covered 12 years. The strategy of the care given in the postoperative intensive care unit and the techniques of myocardial protection may have improved during that period. No postoperative follow-up was done in this study. Prospective multicenter studies involving more patients and establishing a predictive mortality scoring system would more accurately assess the results of CABG in poor LV function patients.

In conclusion, patients with severe LV dysfunction ran a higher risk of mortality and morbidity undergoing CABG. However, the results of CABG in these high-risk patients were acceptable. More sophisticated techniques in anesthesia, surgery, and postoperative care are mandatory in patients with severe LV dysfunction.

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