Original Article

Preoperative Parameters Predicting the Postoperative Course of Endoventricular Circular Patch Plasty

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It is necessary that preoperative factors predicting the postoperative course be easily and precisely documented. We investigated the preoperative predictors and defined the indications of endoventricular circular patch plasty (EVCPP) in patients with ischemic cardiomyopathy (ICM). Between October 1997 and May 2001, 22 patients (19 males and 3 females; mean age 63.4 years, range 50 to 75 years) with ICM underwent EVCPP. Only one patient underwent EVCPP alone. Coronary artery bypass grafting (CABG) associated with EVCPP was performed in 18 patients (82%). Twenty-two patients were divided into two groups according to the outcome after surgery. Group A consists of three patients who died after surgery and two who showed no clinical improvement after surgery. Group B comprises 17 patients who showed clinical improvement in terms of New York Heart Association (NYHA) functional class, freedom from angina or congestive heart failure. The left ventricular systolic dimensions (LVDs) in group A was significantly longer compared with that in group B (p=0.02, 5.8 versus 4.8 cm). They were not statistically different in other variables between the two groups. We analyzed 10 preoperative variables which are categorized as crucial predictors of postoperative course. We found statistically significant differences in LVDs greater than or equal to 5.5 cm and fractional shortening (FS) less than or equal to 15% (p=0.0393, p=0.0207) as well as an increased odds ratio (13, 18.6667, respectively) between A and B groups. In the present study, LVDs and FS demonstrated the dimensional alteration of the cardiac basal segment, and identify the degree of contraction in the nonaneurysmal portion of the ventricle which will remain after surgery. Therefore, LVDs and FS indicating the functional reserve of the basal segment of the ventricle after EVCPP may be the most important parameters predicting the postoperative course. (Ann Thorac Cardiovasc Surg 2002; 8: 363–8)

Key words: ischemic cardiomyopathy, endoventricular circular patch plasty, volume reduction surgery, echocardiography

Introduction

We have recognized the limitation in the efficacy of isolated coronary artery bypass grafting (CABG) for patients with poor left ventricular (LV) function. Therefore, we were searching for a new surgical procedure associated with CABG. Endoventricular circular patch plasty (EVCPP) was introduced to Japan in 1997, and we immediately employed this procedure for the first patient with effort angina and LV aneurysm. Although this procedure has long been considered a possible treatment for LV aneurysmectomy, the concept of volume reduction surgery has recently changed our thinking about the procedure. Nevertheless, in patients with severely impaired cardiac function, preoperative prognostic factors have not been well elucidated. Therefore, it is necessary to iden-

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Table 1. Patients' characteristics

Male/female	19/3
Age (y; mean)	50-75 (63.4)
Previous myocardial infarction	22 (100%)
Congestive heart failure	16 (73%)
Ventricular septal perforation	2 (9%)
Left ventricular wall motion:	
Akinesis/dyskinesis	14/8
Intra-aortic balloon pumping	7 (32%)

Table 2. Operative procedure

EVCPP alone	1
CABG	16
VSP	1
VSP+CABG	1
MVR	1
MVR+TAP	1
MVR+TAP+CABG	1

EVCPP: endoventricular circular patch plasty; CABG: coronary artery bypass grafting; VSP: ventricular septal perforation; MVR: mitral valve replacement; TAP: tricuspid annuloplasty

tify the preoperative factors which allow to predict the postoperative course as easily and precisely as possible. The purpose of this study was to investigate the preoperative predictors and to define the indications for EVCPP in patients with ischemic cardiomyopathy (ICM).

Materials and Methods

Between October 1997 and May 2001, 22 patients (19 males and 3 females) with ICM underwent EVCPP with or without associated procedures for concomitant lesions in our institute (Table 1). All patients (mean age 63.4 years, range 50 to 75 years) had previous myocardial infarctions, and 16 (73%) had at least one episode of congestive heart failure before surgery. Two patients (9%) had ventricular septal perforations (VSP) associated with the LV anterior wall and inferior wall infarction, respectively. Preoperative echocardiography and LV catheterization were aggressively performed in all patients. Left ventricular angiography demonstrated the impaired LV wall motion in 14 patients with akinetic areas and eight patients with dyskinetic areas. Mitral regurgitation was seen in nine patients (41%) and tricuspid regurgitation in two (9%). Seven patients (32%) required the use of intra-aortic balloon pumping (IABP) preoperatively. We used preventative IABP for the first four patients in this study. After that, we used IABP only for the patients with mitral regurgitation or poor LV function. There were no urgent operations in this series.

Only one patient underwent EVCPP alone. CABG associated with EVCPP was performed in 18 patients (82%). Among them, one patient underwent the closure of a small VSP, while another simultaneously underwent mitral valve replacement (MVR) and tricuspid annuloplasty (TAP). Other operative procedures are detailed in Table 2. The operations were performed with the use of cardiopulmonary bypass with intermittent antegrade warm blood or continuous retrograde cold blood cardioplegia for myocardial protection. The internal thoracic artery (ITA) and saphenous vein were employed as conduits of the bypass grafting, and a mechanical prosthetic valve was used when necessary for valve replacement. The technique of EVCPP has been described in detail in a previous paper.[1] We did not control the LV volume during surgery, because the volume could not be managed with the simple plication stitch only in the LV cavity. It is impossible to make the volume the same after surgery in all patients.

Twenty-two patients were divided into two groups according to the outcome after surgery. Group A consists of three patients who died after surgery and two who showed no clinical improvement after surgery. Two patients died of low cardiac output syndrome on postoperative day 11 and 20, respectively. Another patient died suddenly of arrhythmia three months after surgery. Two other patients occasionally suffered from refractory congestive heart failure and consequently had to be admitted to the hospital on several occasions. Group B comprises 17 patients who showed clinical improvement in terms of New York Heart Association (NYHA) functional class, freedom from angina or congestive heart failure. We investigated the episodes of critical arrhythmia such as spontaneous ventricular tachycardia (VT) in the postoperative course, and only one patient with VT was documented in both groups. Preoperative clinical characteristics by group are shown in Table 3.

We retrospectively evaluated several factors which may have affected postoperative results: NYHA functional class; LV ejection fraction (LVEF), end-diastolic volume index (LVEDVI) and end-systolic volume index (LVESVI) of the left ventricle on LV angiography; LV diastolic dimension (LVDd), LV systolic dimension (LVDs), and fractional shortening (FS) on echocardiography; as well as hemodynamic data on right

Table 3. Preoperative clinical characteristics by group

Variable	Group A (n: 5)	Group B (n: 17)	p-value
Age (years)	62±9	64±6	0.58
Male/female	5/0	14/3	
Hypertension	0	7 (41%)	0.13
Diabetes mellitus	2 (40%)	9 (53%)	>0.99
Hyperlipidemia	0	5 (29%)	0.29
Congestive heart failure	4 (80%)	12 (71%)	>0.99
Spontaneous VT	1 (20%)	1 (6%)	0.41
Ventricular septal perforation	0	2 (12%)	>0.99
Mitral regurgitation	3 (60%)	6 (35%)	0.61
LV wall motion			
Dyskinesis	3 (60%)	5 (29%)	0.31
Akinesis	2 (40%)	12 (71%)	0.31

VT: ventricular tachycardia; LV: left ventricle

Table 4. Preoperative angiographic, echocardiographic and hemodynamic data by group

Variable	Group A (n: 5)	Group B (n: 17)	p-value
NYHA functional class	3±1	3±1	>0.99
LVEF (%)	24±6	30±6	0.08
LVEDVI (ml/m^2)	133.5±7.9 (n=4)	143.7±30.9	0.53
LVESVI (ml/m^2)	101.5±8.8 (n=4)	96.2±23.9	0.62
LVDd (cm)	6.8±0.5	6.1±0.8	0.10
LVDs (cm)	5.8±0.4	4.8±0.8	0.02
FS (%)	16±2	22±8	0.11
HR (b/min)	71±6 (n=3)	75±13	0.64
CI (L/min/m^2)	2.31±0.39	2.71±0.88	0.35
PCWP (mmHg)	13±8	13±7	>0.99

NYHA: New York Heart Association; LVEF: left ventricular ejection fraction; EDVI: end diastolic volume index; ESVI: end systolic volume index; LVDd: left ventricular diastolic dimension; LVDs: left ventricular systolic dimension; FS: fractional shortening; HR: heart rate; CI: cardiac index; PCWP: pulmonary capillary wedge pressure

cardiac catheterization. Left ventricular wall motion was analyzed with the biplane centerline method. The following preoperative variables were analyzed to recognize their value as predictive parameters of postoperative mortality and morbidity: NYHA functional class III and IV, LVEF less than or equal to 20%, LVDd greater than or equal to 6.5 cm, LVDs greater than or equal to 5.5 cm, FS less than or equal to 15%, LVEDVI greater than or equal to 155 ml/m^2, LVESVI greater than or equal to 110 ml/m^2, pulmonary capillary wedge pressure (PCWP) greater than or equal to 18 mmHg, cardiac index (CI) less than or equal to 2.2 l/min/m^2, and mitral regurgitation greater than or equal to II/IV.

The baseline characteristics, preoperative clinical data and predictive parameters for the groups of patients were compared using chi-square analysis or Fisher's exact test. The odds ratio and their 95% confidence intervals (*CI*) for outcome were calculated accordingly.

Results

Group A consists of five male patients with a mean age of 62 years. Three of them (60%) had mitral regurgitation and dyskinetic LV wall motion. Group B consists of 14 male and 3 female patients (mean age 64 years) and includes two patients (12%) with ventricular septal perforation and 12 patients (71%) with akinetic LV wall motion. There was an extremely high prevalence of con-

Table 5. Preoperative predictive variables

Variable	p-value	Odds ratio	(95% *CI*)
NYHA class III	>0.999	0.81818	(0.1-6.3)
LVEF 20%	0.1169	10.6667	(0.7-158.5)
LVDd 6.5 cm	0.1353	7.3333	(0.7-81.4)
LVDs 5.5 cm	0.0393	13	(1.1-152.4)
FS 15%	0.0207	18.6667	(1.5-232.3)
LVEDVI 155 ml/m^2	0.2663	0	
LVESVI 110 ml/m^2	>0.999	0.8	(0.1-9.7)
PCWP 18 mmHg	>0.999	1.6	(0.2-12.7)
CI 2.2 L/min/m^2	>0.999	1.2222	(0.2-9.5)
MR II	0.3089	3.6	(0.5-28.6)

NYHA: New York Heart Association; LVEF: left ventricular ejection fraction; LVDd: left ventricular diastolic dimension; LVDs: left ventricular systolic dimension; FS: fractional shortening; EDVI: end diastolic volume index; ESVI: end systolic volume index; PCWP: pulmonary capillary wedge pressure; CI: cardiac index; MR: mitral regurgitation

gestive heart failure (group A, 80% and group B, 71%) in both groups. However, there were no significant differences in preoperative clinical variables between the two groups (Table 3). Preoperative angiographic, echocardiographic and hemodynamic data are shown in Table 4. The LVDs in group A was significantly longer compared with that in group B (p=0.02, 5.8 versus 4.8 cm). The LVEF, FS, heart rate (HR) and CI in group A were lower than those in group B. However, they were not statistically different between the two groups. There were no significant differences in angiographic LVEDVI and LVESVI between the two groups.

We analyzed 10 preoperative variables which are categorized as crucial predictors of postoperative course in Table 5. We found statistically significant differences in LVDs greater than or equal to 5.5 cm and FS less than or equal to 15% (p=0.0393, p=0.0207) as well as an increased odds ratio (13, 18.6667, respectively) between A and B groups. A couple of variables (LVEF less than or equal to 20% and LVDd greater than or equal to 6.5 cm) revealed an efficient odds ratio though the difference was not statistically significant. In this analysis, hemodynamic parameters demonstrated no significant differences. The relationship between FS and LVDs is shown in Fig. 1. Five patients who died or unimproved after surgery can be seen in a confined area around LVDs of 5.5 cm and FS of 15%.

Discussion

The concept of ventricular volume reduction surgery for patients with ICM has become common in the field of surgical management.[2-4] Dor and colleagues[5,6] introduced this concept to the surgical treatment for patients with LV aneurysm and/or end-stage dilated cardiomyopathy. This surgical concept was simultaneously introduced in Japan with partial left ventriculectomy (Batista operation[7]) and spread rapidly as an alternative treatment for ICM. We consequently employed this operation for the first patient with multi-vessel disease and LV aneurysm

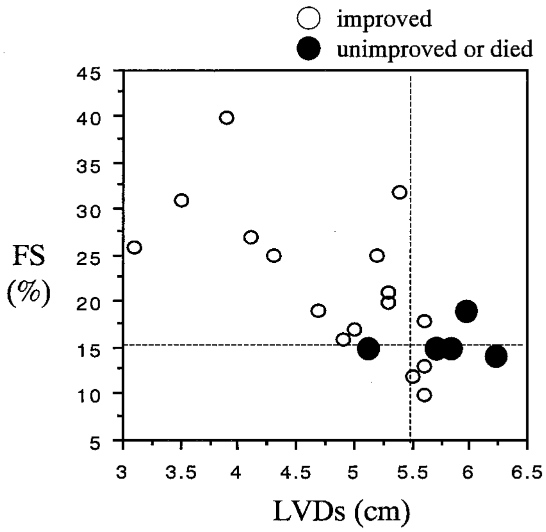

Fig. 1. FS-LVDs rerationship.
Patients unimproved or died after surgery are confined to a rather narrow area with LVDs of 5.5 cm and FS of 15%.

due to anterior and inferior myocardial infarction. CABG was concomitantly performed with EVCPP, and a favorable postoperative course was obtained. The second patient was successfully operated on using EVCPP and mitral valve replacement, and he followed a satisfactory postoperative course without any complications. Subsequently we began to apply the concept of volume reduction to surgical management for patients with ICM. In this study we employed the definition of ICM introduced by Bart and coworkers[8] in 1997. They argued that the etiology of disease was considered to be ICM if the patients had an LVEF less than 40% and a history of myocardial infarction, percutaneous transluminal coronary angioplasty, CABG, or at least one major coronary artery with greater than 75% stenosis.

Surgical management for ICM is expected to improve through coronary artery revascularization and LV reconstructive surgery such as LV aneurysmectomy or EVCPP. Mills and associates[9] reviewed the technical advantages in this treatment of LV aneurysm: the left anterior descending artery (LAD) was preserved and bypassed, thick felt readily conformed to the irregular LV trabeculated wall, no prosthetic material was in contact with the pericardial surface, and favorable LV geometry was maintained. Furthermore, concomitant CABG may preserve the remaining viable myocardium in selected patients with ischemia and poor LV function.[10] It is likely that the additional procedures including VSP closure, MVR and TAP benefited from the effects produced in association with CABG and EVCPP.

The predictive risk factors of the postoperative course after surgical treatment for ICM are unclear and are still being investigated. Yamaguchi and coworkers[11] reported that CABG was useful as a treatment for ICM and that a preoperative LVESVI of greater than 100 ml/m^2 demonstrated by LV angiography might be an independent predictor of the development of postoperative heart failure. However, they did not evaluate the advantages of the resection of the infarcted LV wall. Cosgrove and colleagues[12] noted that emergent procedure, advancing age, left main coronary stenosis and history of congestive heart failure might be risk factors for mortality of the LV wall resection. Barrat-Boyes and associates[13] identified worsening NYHA functional class, presence of congestive heart failure requiring diuretics, and extensive coronary disease as risk factors for early death after LV aneurysmectomy. Furthermore, they indicated that the risk of late mortality was increased by significant right coronary artery stenosis and by poor contractility of the posterobasal segment.

However, there were few reports describing the indication and the predictor of EVCPP. Di Donato and coworkers[14-16] had advocated that the independent predictors of early mortality in EVCPP were the duration of the cardiopulmonary bypass, the critical involvement of the circumflex artery and the nonuse of the ITA on the LAD. They represented some clinical and hemodynamic factors as independent predictors that were easy to measure, such as preoperative depressed CI, advanced mean pulmonary artery pressure and developed renal insufficiency. But we confirmed that there were no significant differences, not only in angiographic parameters but also in hemodynamic parameters in our study. The hemodynamic parameters (PCWP and CI) are easily affected by the medical intervention of diuretics and catecholamines. Furthermore, the functional parameters (EF, LVEDVI, and LVESVI) demonstrated on preoperative angiography may prove insufficient when we predict LV function after the repair of dilated LV, as these parameters depict the condition of the entire LV cavity before the myocardial resection. Approximately one-third of the LV cavity in most cases may be resected and/or excluded by the technique of EVCPP.

Echocardiography had been performed in all patients waiting for surgery in our institute, because this noninvasive test facilitated demonstrating the geometric information of impaired LV function without inducing fatal arrhythmia or volume overload. Accordingly, we tried employing the preoperative parameters measured by echocardiography in order to predict the outcome in the postoperative course. In the present study, LVDs and FS revealed significant differences and an increased odds ratio. These parameters demonstrate the dimensional alteration of the cardiac basal segment, and identify the degree of contraction in the nonaneurysmal portion of the ventricle which will remain after surgery. Therefore, LVDs and FS indicating the functional reserve of the basal segment of the ventricle after EVCPP may be the most important parameters predicting the postoperative course. We may expect to obtain a satisfactory outcome in the surgical management of patients with severe LV dysfunction by the preoperative assessment of these predictors.

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