



Outcomes of Percutaneous Coronary Interventions for Left Main Coronary Artery Stenoses at a Hospital

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Background: According to the American College of Cardiology/American Heart Association guidelines, percutaneous coronary intervention (PCI) for left main coronary artery (LMCA) stenosis is contraindicated unless the patient is not eligible for coronary artery bypass graft surgery (CABG). The aim of this study was to analyze the immediate and late outcomes of PCIs for unprotected left main coronary stenoses at the Tri-Services General Hospital, Taipei, Taiwan. **Methods:** Design: Retrospective follow-up study. Patients: Seventeen patients were enrolled in the study between October 2002 and March 2005. Eleven patients presented with stable angina and underwent the procedure electively and six patients presented with acute coronary syndrome and received the procedure emergently. Interventions: Two patients received balloon dilatation only. Express Stents (Boston Scientific, United States) were used in ten patients, four patients received Taxus Express2 paclitaxel-eluting stents (Boston Scientific, United States), and one received an R stent (Orbus Medical Technologies, Netherlands). Main outcome measures: Procedural success rate and major cardiac events. **Results:** Intervention was successful in 16 of 17 patients. One emergent procedure failed because of total occlusion of the LMCA followed by cardiogenic shock. No immediate complications during the procedures or major cardiac events were detected in successfully treated patients. There were two noncardiac deaths during hospitalization. During the late follow-up period (mean, 20.2 months), no major adverse cardiac events occurred. Five patients received repeated coronary angiography and there were no recurrences of significant stenoses in previously treated left main coronary arteries. **Conclusions:** Elective stenting of an unprotected LMCA stenosis should be considered as a feasible, safe, and effective approach for treatment of appropriate lesions.

Key words: left main coronary artery, left main stenosis, percutaneous coronary intervention

INTRODUCTION

In recent years, percutaneous coronary intervention (PCI) has been widely applied to treat most types of atherosclerotic coronary artery disease. In contrast to its initial reception as a therapeutic novelty, PCI was performed on more than 900,000 patients in 2003 in the United States, far exceeding the number of patients who underwent coronary artery bypass graft (CABG) surgery, which has been falling by 10% per year. However, one of the few remaining contraindications for PCI is stenosis of the left main coronary artery (LMCA). The American

College of Cardiology (ACC)/American Heart Association (AHA) guidelines exclude PCI as the first-considered therapeutic modality for patients suffering from chronic and unstable angina pectoris.¹ Because of the accumulation of experience in performing PCI, technical advances, and the use of additional devices, the role of PCI for patients with unprotected left main coronary stenosis warrants reexamination.

We analyzed the early and delayed results of 17 patients who underwent PCI of the unprotected LMCA at our hospital.

METHODS

Patients

Retrospectively, we identified all patients who underwent PCI of significant stenoses of the unprotected LMCA between October 2002 and March 2005. The data were obtained by reviewing charts, angiographic film, and reports generated in our hospital.

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Table I. Patient baseline variables.

Patient number	Age	Sex	Risk factor (*)	Previous MI	Emergency /Elective	Previous CABG	Other diseased vessels	Additional angioplasty (*)	Location in LMCA	Calcification	IABP used	DES/ BMS	RVD (mm)	Complex technique used
1	79	F	a,b,c	–	Elective	–	LCX	LCX	Ostium	+	–	DES	3.8	Rotablator atherectomy
2	62	M	b	+	Elective	–	–	–	Ostium	–	–	BMS	3.5	–
3	69	M	b,c	–	Elective	–	LCX LAD	LCX LAD	Ostium	+	–	BMS	3.7	–
4	68	F	a,b,c	–	Elective	+	LAD LCX	LAD	Ostium	–	–	BMS	3.1	–
5	68	F	a,b	–	Elective	+	LAD LCX RCA	–	Ostium	–	–	BMS	4.2	–
6	73	M	–	–	Elective	+	LAD RCA LCX Vein graft to LAD	Vein graft to LAD LCX	Distal with bifurcation involved	–	–	BMS	3.8	Kissing balloon
7	67	M	c	+	Elective	+	LAD LCX RCA	RCA	Distal	–	–	BMS	3.2	–
8	65	M	a,b,c	–	Elective	–	LAD RCA LCX	RCA LAD	Distal with bifurcation involved	+	–	DES	3.6	Rotablator atherectomy Kissing balloon
9	79	M	a,b,c	–	Elective	–	LAD RCA LCX	LAD	Distal with bifurcation involved	–	–	BMS	3.7	Kissing balloon
10	79	M	a,b	–	Elective	–	LAD	LAD	Distal with bifurcation involved	–	–	DES	3.0	Kissing balloon
11	50	M	c	–	Elective	–	LAD LCX RCA	LAD	Ostium	–	–	DES	3.8	–
12	85	M	b,c	–	Emergency	–	LAD LCX RCA	LAD LCX	Distal with bifurcation involved	+	–	BMS	3.6	Rotablator atherectomy Kissing balloon
13	96	F	b	–	Emergency	–	LAD LCX	LAD LCX	Distal with bifurcation involved	–	+	DES	3.2	Kissing balloon
14	85	F	b	–	Emergency	–	–	–	Ostium	–	–	BMS	3.8	–
15	88	M	–	–	Emergency	–	RCA LAD	–	Ostium	–	+	–	3.1	–
16	85	F	–	–	Emergency	–	LAD LCX RCA	LAD	Ostium	–	–	BMS	4.0	–

Risk factor (*): a, diabetes mellitus; b, hypertension; c, hyperlipidemia.

Additional angioplasty (*): additional angioplasty during the same procedure.

LAD, left anterior descending coronary artery; LCX, left circumflex coronary artery; RCA, right coronary artery; IABP, intra-aortic balloon pump; DES, drug-eluting stent; BMS, bare-metal stent; RVD, reference vessel diameter.

Stenting of a left main coronary stenosis was performed on 15 patients and balloon dilatation only was applied to two patients. Eleven men and six women were included in the study.

The mean age of the participants was 80.8 years. Two patients had previously suffered from MI. Seven patients had previously undergone angioplasty; two patients had received coronary artery bypass graft surgery and another

two patients had received both procedures. Two patients had unique lesions of the LMCA and 15 patients had concomitant multiple vessel disease. Six patients underwent emergency angioplasty because of acute coronary syndrome. Table I summarizes baseline variables pertaining to patient characteristics and coronary angiography. Total occlusion of the LMCA was noted in one patient.

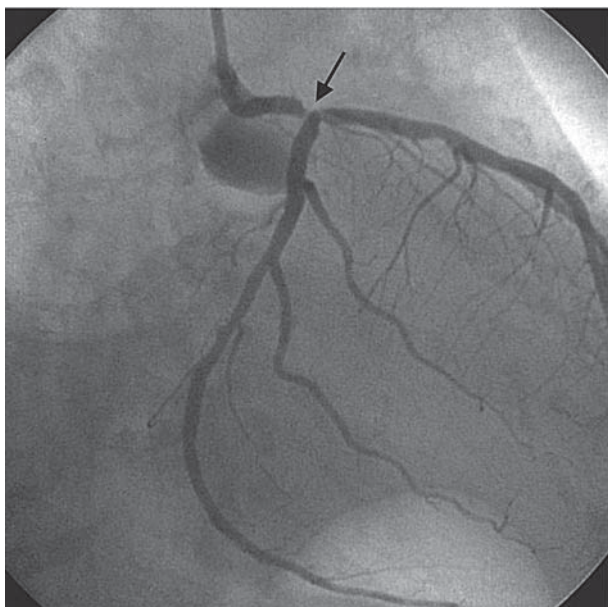


Fig. 1 Coronary angiogram showing a 70% stenosis (black arrow) of the distal part of the left main coronary artery. The lesion is located near the ostium of the left anterior descending artery in this right-anterior oblique view.

Technical Approach

Fifteen patients received the procedure with a standard percutaneous transfemoral approach and two patients received it with a transradial approach in which the monorail dilatation system was used with a 0.014 inch intracoronary guidewire. Another two patients received balloon dilatation only. Express stents (Boston Scientific, United States) were used in 10 patients, four patients received Taxus Express2 paclitaxel-eluting stents (Boston Scientific, United States), and one received an R stent (Orbus Medical Technologies, Netherlands). One patient was treated with a Rotablator before stenting because of extensive calcification. Intra-aortic balloon pumps were inserted into two patients during the procedure. During the procedure, all patients received 10,000 U of heparin intravenously. After the procedure, patients were continuously infused with heparin concomitant with intravenous administration of glyceryl trinitrate. After the procedure, all patients received aspirin and stented patients also received clopidogrel. Angiography was performed during the follow-up period on patients who displayed signs of myocardial ischemia.

Data Analysis

LMCA stenosis was defined as a stenosis greater than 70% as assessed by quantitative coronary angiographic

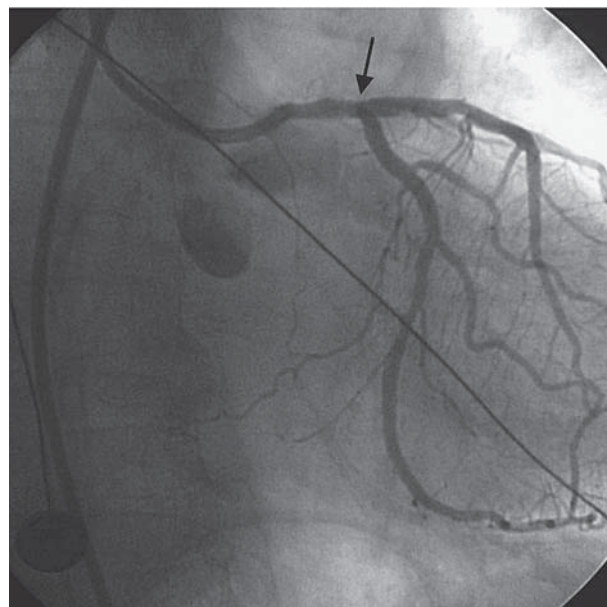


Fig. 2 After coronary intervention with stent (black arrow) deployment to the left main stenosis shown in Fig. 1, there was no significant residual stenosis.

(QCA) analysis. Successful angioplasty was defined as residual stenosis of less than 20% without immediate major complications (i.e., death, acute coronary syndrome, coronary artery bypass surgery, or repeat angioplasty). Restenosis was defined as a stenosis of more than 50% at follow-up.

RESULTS

Procedural and Early Results

Successful LMCA intervention was achieved in 16 of 17 patients. One patient received coronary intervention emergently because of unstable angina; total occlusion of the LMCA was disclosed after diagnostic angiography. Balloon dilatation was performed on this patient, who had a residual stenosis of 50%. Unfortunately, acute pulmonary edema and cardiogenic shock developed during the procedure and emergent coronary bypass graft surgery was performed. The progress of the patient at the clinic was monitored continuously and the outcome was good. Figures 1 and 2 show a successful stent implantation in the LMCA. Intra-aortic balloons were used for two patients because of cardiogenic shock. In three cases, Rotablator atherectomy was used because of extensive calcification. Five patients received kissing balloon dilatation after LMCA stenting for bifurcation lesions. Additional angioplasties of coronary arteries other than the LMCAs were performed

on 13 patients without immediate complications. During hospitalization, one patient died of complications of Perm catheter implantation and another patient died because of pneumonia and septic shock. Death, coronary bypass surgery, and repeated angioplasty of the LMCA were not observed among successful patients during the hospital phase.

Procedural Variables

The mean implanted stent diameter was 3.5 mm. In the two patients who received balloon dilatation only, the mean inflated balloon pressure was six atmospheres. In stented patients, the inflated balloon pressure was 10-16 atmospheres. In all successfully treated patients, antegrade flow through the LMCA improved and no technical complications such as dissection, acute closure, perforation, or thromboembolism occurred.

Delayed Results

Late follow-up data were available for 15 of the 17 patients. Two patients expired during the one-month hospitalization period after the procedure because of noncardiogenic disease. The mean duration of the follow-up period was 20.2 months. Table II shows the results of QCA analysis and Table III lists the follow-up clinical data. At the time of the follow-up, no patient had suffered from nonfatal acute myocardial infarction. Five patients received repeat coronary angiography because of symptoms of myocardial ischemia. The interval between left main coronary intervention and repeat coronary angiography was 0.5-19 months. All five patients had patent stented LMCAs without significant restenosis. Figure 3 shows the subsequent angiography of the patient presented in Figs 1 and 2. Nine patients were free of symptoms at follow-up. One patient suffered from a transient ischemia attack three months after the coronary intervention.

DISCUSSION

The three-year mortality rate of cases of left main coronary stenosis treated only with drugs was at least 50% during the 1970s.²⁻⁴ Percutaneous coronary intervention is

Table II. Quantitative coronary angiographic analysis

Patient number	Preintervention			Postintervention stenosis			Lesion length (mm)	Acute gain (mm)	Follow-up			Late loss (mm)
	RD (mm)	MLD (mm)	Stenosis	RD (mm)	MLD (mm)	Stenosis			RD (mm)	MLD (mm)	Stenosis	
1	3.82	1.82	52%	3.83	3.45	10%	10.2	1.63	—	—	—	—
2	3.53	0.94	73%	3.60	3.38	6%	9.8	2.44	—	—	—	—
3	3.75	0.91	76%	3.80	3.34	12%	10.5	2.43	3.74	2.52	33%	0.82
4	3.16	1.39	56%	3.16	3.0	5%	11.3	1.61	—	—	—	—
5	4.20	0.92	78%	4.22	3.58	15%	5.4	2.66	4.23	2.85	33%	0.73
6	3.82	1.34	65%	3.84	3.15	18%	8.9	1.81	—	—	—	—
7	3.23	1.09	66%	3.23	3.07	5%	6.4	1.98	3.22	2.24	30%	0.83
8	3.65	0.91	75%	3.68	3.53	4%	10.2	0.91	3.66	3.29	10%	0.24
9	3.77	1.06	72%	3.80	3.53	7%	12.1	2.47	3.75	2.81	25%	0.72
10	3.08	1.05	66%	3.2	2.78	13%	8.9	1.73	—	—	—	—
11	3.80	0.38	90%	3.82	3.67	4%	8.8	3.29	—	—	—	—
12	3.62	1.27	65%	3.65	3.43	6%	10.6	2.16	—	—	—	—
13	3.23	0.84	74%	3.23	2.97	8%	6.9	2.13	—	—	—	—
14	3.82	0.81	79%	3.84	3.49	9%	7.3	2.68	—	—	—	—
15	3.16	0	100%	3.20	1.60	50%	10.4	1.6	—	—	—	—
16	4.04	1.33	767%	4.04	3.56	12%	9.5	2.23	—	—	—	—
17	3.08	0.86	72%	3.20	2.94	8%	7.3	2.08	—	—	—	—

RD, reference vessel diameter; MLD, minimal luminal diameter.

—, data not available.

associated with a risk of acute closure of the vessel and may result in immediate death. From 1992 to 2001, the average periprocedural mortality of PCI of the LMCA was about 8.8 %, which is greater than that for CABG (< 5%).⁵⁻¹⁰ Therefore, the ACC/AHA guidelines discouraged PCI of the LMCA for stable or unstable angina patients.

Although many adverse reports of percutaneous left main coronary intervention were published in the past, this procedure is still attractive to cardiologists because the LMCA is in a proximal position and is relatively large. Moreover, the introduction of stents has improved the short-term success rates and long-term outcomes of interventional cardiology. In recent years, the drug-eluting stent has been widely used and has a low restenosis rate relative to that of the bare stent.¹¹ The introduction of these new medical devices warrants reconsideration of the safety and efficacy of treating stenotic LMCA patients with PCI.

Our results support stenting of the unprotected LMCA as a good option under elective conditions. Of six patients who received PCI emergently, only one patient was not successfully treated with LMCA intervention as a result of total occlusion of the LMCA. The in-hospital major cardiac event rate was nil. In addition, the late follow-up results of our patients were excellent. Although five patients received repeated coronary angiography because of angina, subsequent angiograms showed no evidence of

Table III. Follow-up results

Patient number	Procedural success	In-hospital event	Follow-up duration after discharge (months)	Events during follow-up	Repeated coronary angiography
1	+	–	15	–	Not done
2	+	–	15	–	Not done
3	+	–	27	Angina	No significant LMCA restenosis
4	+	Expired because of complications of permanent catheter implantation	0	Unavailable	Unavailable
5	+	–	25	Angina	No significant LMCA restenosis
6	+	–	13	–	Not done
7	+	–	32	Angina	No significant LMCA restenosis
8	+	–	20	Angina	No significant LMCA restenosis
9	+	–	20	Angina	No significant LMCA restenosis
10	+	–	20	–	Not done
11	+	–	19	–	Not done
12	+	–	21	–	Not done
13	+	–	20	Transient ischemia attack	Not done
14	+	Expired because of pneumonia	0	Unavailable	Unavailable
15	–	Emergent CABG	31	–	Not done
16	+	–	6	–	Not done
17	+	–	20	–	Not done

restenosis in previously implanted left main coronary stents. One patient received drug-eluting stents and the others received bare stents. The results imply that the large diameter of the LMCA decreases the restenosis rate of bare stenting. However, in the largest published study to date, the results of elective PCI with sirolimus-eluting stents in 102 patients with left main coronary disease were compared with a 121-patient bare-metal stent historical control cohort.¹² At six months after surgery, the rate of angiographic restenosis was 7% in the drug-eluting stent group compared with 30% in the bare-metal stent group. The relatively shorter follow-up periods and smaller number of cases in our study possibly eliminated differences in clinical outcomes between the drug-eluting stent and the bare-metal stent.

Eight of 16 of our successfully treated patients had distal LMCA lesions involving the ostium of the left anterior descending artery or the left circumflex artery. Only one stent was implanted in each bifurcation lesion. Five patients received kiss balloon dilatation after bifurcation stenting and two patients received Rotablator

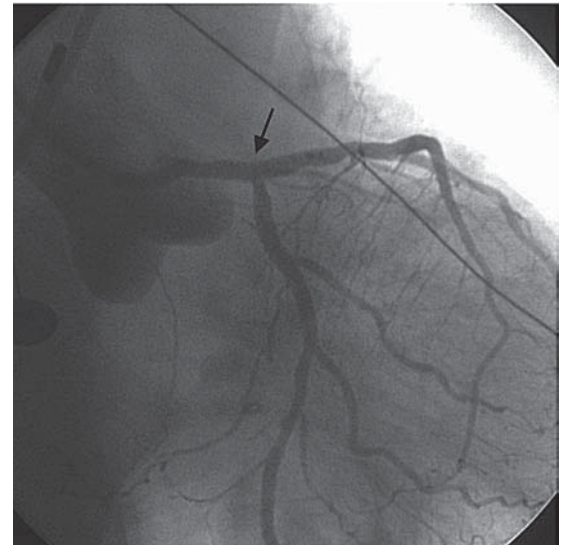


Fig. 3 Angiogram obtained six months after left main stenting of the artery shown in Figs 1 and 2. No significant left main coronary artery restenosis is evident.

atherectomy for extensive calcification. According to previous publications, stenting of the LMCA was performed mainly in the ostial or middle portion.^{13,}

¹⁴ High success rates and good late results were reported in these studies. Another report indicated that, although drug-eluting stents have improved the outcomes of patients undergoing PCI for LMCA disease, management of disease at the distal left main bifurcation is still associated with a nontrivial incidence of restenosis.¹⁵ Our results show that distal LMCA stenting is as safe and effective as the stenting in other portions of the LMCA in the early and late follow-up periods. Two patients received balloon dilatation of the LMCA without having stents implanted. One of these patients had a poor immediate result (cardiogenic shock) and the other had an excellent long-term result. This indicates that stent implantation should be applied to all LMCA interventions because stents provide protection against local complications such as recoil and dissection and help to prevent restenosis.

These data should be interpreted cautiously because the study involved comparatively small numbers of patients. Furthermore, the study was retrospective and did not include a simultaneous randomized control group. Larger prospective series should be conducted to clarify whether the results of unprotected LMCA stenting, including stenting of bifurcation lesions, are as favorable as those of coronary artery bypass surgery.

CONCLUSION

Our results show that elective stenting of unprotected LMCA stenoses is feasible, safe, and effective. Even in cases of bifurcation of LMCA lesions, which have been excluded from many other studies, the outcome of percutaneous coronary intervention is encouraging. However, in emergent situations, coronary intervention should not be considered a definitive procedure for LMCA stenoses, but a bridge to coronary artery bypass surgery.

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