

ACUTE LEFT MAIN CORONARY ARTERY OBSTRUCTION WITH MYOCARDIAL INFARCTION

— Reperfusion Strategies, and the Clinical and Angiographic Outcome —

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We studied the clinical and angiographic outcomes in 8 patients with acute left main coronary artery obstruction. Intracoronary thrombolysis with 1.2×10^5 units of urokinase was performed in 3 patients during preparation for percutaneous transluminal coronary angioplasty (PTCA), and failed in all 3 cases. In 2 patients, the left main coronary artery was recanalized by intracoronary thrombolysis with 3.6 and 4.8×10^5 units of urokinase, respectively. PTCA was attempted either before or after intracoronary thrombolysis in 5 patients and achieved reperfusion in all 5 cases. However, 2 of the 8 patients had persistent high-grade residual stenosis 69% and 89% luminal reduction, respectively. Emergency coronary artery bypass grafting was successfully performed in these 2 patients, and both are currently alive. Although intraaortic balloon counterpulsation was performed in all 8 patients, 2 died acutely from pump failure in the catheterization laboratory. One patient died later due to congestive heart failure. The factors favoring survival were right coronary artery dominance and a well-developed collateral circulation.

Our findings suggest that PTCA is a useful strategy for reperfusion following acute left main coronary artery occlusion. When PTCA cannot achieve sufficient revascularization, emergency coronary artery bypass grafting should be performed. To control pump failure, intraaortic balloon counterpulsation is insufficient in some cases and more aggressive measures may be required.

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LEFt main coronary artery obstruction associated with acute myocardial infarction is quite rare! Much of the myocardium of the left ventricle is perfused by the left main coronary artery, so its acute ob-

struction in the absence of adequate collateral circulation causes cardiogenic shock and is usually rapidly fatal?

Reperfusion therapy has become a common treatment for acute myocardial infarction³ and has recently been attempted for patients with cardiogenic shock following acute myocardial infarction⁴. There have been some reports of acute left main coronary artery obstruction^{5,6} but each series

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TABLE I PATIENT CHARACTERISTICS

Case#	Age	Sex	Shock	sBP
1	61	M	+	50
2	70	M	+	70
3	55	M	+	76
4	63	M	+	40
5	62	M	—	104
6	67	M	+	80
7	62	M	+	60
8	57	M	+	82

Abbreviation. sBP, systolic blood pressure (mmHg).

included only 1 survivor. Accordingly, evaluation of the influence of the method of reperfusion on the clinical outcome in patients with acute left main coronary obstruction is extremely difficult. In fact, only 1 study⁷ which included a considerable number of patients has investigated the influence of reperfusion strategy on the clinical outcome in this context, and the correct reperfusion strategy to adopt for acute left main coronary artery obstruction remains unclear.

We have treated 8 patients with acute left main coronary artery obstruction in the past 3 years. In this report, we describe the reperfusion procedures we used, and the clinical and angiographic outcomes in these 8 patients. We also compare the results with the only available previous report.

SUBJECTS

A total of 8 patients with acute left main coronary artery obstruction were admitted to our hospital from 1988 to 1991. Their clinical characteristics are shown in Table I. All 8 patients were men between 55 and 70 years old (mean \pm SD: 63 ± 4 years). Seven patients presented with cardiogenic shock.

The angiographic and hemodynamic findings, the treatment strategy, and the clinical outcome are summarized in Table II.

Angiographic findings

Right coronary angiography could not be performed in 1 patient due to extremely poor hemodynamics. Good collaterals were observed in 3 of the 7 patients 43% in whom right coronary angiography could be performed before reperfusion therapy. The left

main coronary artery had already recanalized spontaneously in 1 case, but showed subtotal or total obstruction in the remaining 7 patients (Table II).

Electrocardiographic findings

ST segment elevation in the precordial leads was seen in 4 of the 8 patients (Table III), while ST depression was observed in the other 4. ST segment depression in leads II, III, and/or aVF was seen in all 8 patients.

RESULTS

Treatment Strategy and Acute Outcome

While preparations were made for emergency percutaneous transluminal coronary angioplasty (PTCA), intracoronary thrombolysis was performed in 6 patients. The other 2 patients were treated directly with PTCA. Initially, 1.2×10^5 units of urokinase was given by bolus intracoronary infusion, followed by infusion at a rate of 0.24×10^5 units/min. Emergency PTCA was performed according to standard methods using a flexible, movable guide wire and a balloon catheter.

Initial intracoronary thrombolysis with 1.2×10^5 units of urokinase failed to achieve reperfusion in 3 patients (Table II). Because their poor hemodynamic condition and the uncertainty of achieving successful reperfusion by thrombolysis did not allow us to continue thrombolytic therapy in these patients, we performed PTCA immediately after bolus administration of urokinase. Two patients had better hemodynamics, which allowed us to administer more than 1.2×10^5 units of urokinase, and the left main coronary artery was recanalized to a residual stenosis of 56% and 54%, respectively. Approximately 20 min was required to achieve recanalization. In these 2 patients, since antegrade flow of TIMI grade III was achieved after thrombolysis, PTCA was not attempted. In the patient with spontaneous recanalization, urokinase was administered but the grade of residual stenosis did not change.

PTCA was attempted in 5 patients, including the 3 who failed thrombolysis with 1.2×10^5 units of urokinase, and successful revascularization was achieved in all 5 patients. The grade of residual stenosis in

TABLE II STRATEGY FOR TREATMENT AND ANGIOGRAPHIC, HEMODYNAMIC AND CLINICAL OUTCOMES

Case#	LMCA	Other Lesions	Dominant Artery	R→L Collat.	therapy	Residual Stenosis	Onset-Recanal. time	Post-Reperfusion				Outcomes
								C.I	PCW	PAP	CVP	
1	sub.	none	rt	G-1	icUK (120000U) PTCA	→100% →15%	130 min	—	—	—	—	died (2 h)
2	sub	LAD (100%)	rt	LAD; G-4 LCx; G-1	primary PTCA	→7%	185 min	3.06	11	26/16	—	alive
3	100%	none	rt	G-1	icUK (360000U)	→56%	240 min	2.47	32	52/24	19	alive
4	100%	unknown	unknown	unknown	primary PTCA	→54%	210 min	—	—	—	—	died (5 h)
5	69%*	RCA (100%)	rt	G-1	icUK (480000U) urgent CABG	→69%	<120 min	2.80	12	35/14	8.8	alive
6	100%	none	rt	G-4	icUK (480000U)	→54%	240 min	1.97	22	48/22	16	died (42d)
7	100%	RCA (50%)	rt	LAD; G-4 LCx; G-1	icUK (120000U) PTCA urgent CABG	→100% →89%	345 min	5.31	14	31/14	—	alive
8	100%	RCA (50%)	rt	G2	icUK (240000U) PTCA	→100% →17%	120 min	2.21	22	31/21	—	alive

Extent of collateral circulation was divided into 4 grades as follows: grade 1 (G-1); none, grade 2 (G-2); filling of side branches of the artery perfused via collateral vessels without visualization of the epicardial segment, grade 3 (G-3); partial filling of the epicardial segment via collateral vessels, grade 4 (G-4); complete filling of the epicardial segment via collateral vessels. *; the LMCA was already recanalized when emergent coronary angiography was performed. Abbreviations. LMCA, left main coronary artery; Collat, Collaterals; LAD, left anterior descending coronary artery; RCA, right coronary artery; LCx, left circumflex coronary artery; rt, right; ic, intracoronary; UK, urokinase; C.I., cardiac index (l/min²); PCW, pulmonary capillary wedge pressure (mmHg); PAP, pulmonary artery pressure (mmHg); CVP, central venous pressure (cmH₂O); PTCA, percutaneous transluminal coronary angioplasty.

TABLE III ST SEGMENT CHANGES IN THE ADMISSION 12-LEAD ELECTROCARDIOGRAMS

Case#	I	II	III	aV _R	aV _L	aV _F	V ₁	V ₂	V ₃	V ₄	V ₅	V ₆
1	↑↑	↓↓	↓	↑	↑↑	↓↓	—	↑↑	↑↑	↑↑	↑↑	↑↑
2	—	↓↓	↓	↑	—	↓↓	—	↓↓	↓↓	↓↓	↓↓	↓↓
3	↓	↓	—	↑	↓	—	—	↓↓	↓↓	↓↓	↓↓	↓↓
4	—	↓	↓	—	—	↓	—	↑	↑	↑	—	—
5	↓	↓↓	↓↓	↑	—	↓↓	↑↑	↑↑	↑↑	↑↑	↑↑	↓
6	—	↓↓	↓	↑	↑↑	↓↓	↓↓	↓↓	↓↓	↓↓	↓↓	↓↓
7	↑	↓↓	↓	↓	↑	↓↓	↓↓	↓↓	↓↓	↓↓	↓↓	↓↓
8	—	↓	↓	—	↑	↓	↑	↑	↑	—	—	—

↓, ST depression ≥ 0.1 mV to < 0.2 mV; ↓↓, ST depression ≥ 0.2 mV; ↑, ST elevation ≥ 0.1 mV to < 0.2 mV; ↑↑, ST elevation ≥ 0.2 mV; —, ST deviation within ± 0.1 mV.

TABLE IV CATHETERIZATION DATA IN THE CHRONIC PHASE

Case#	LMCA	LVG EF (%)	EDVI (ml/m ²)	ESVI (ml/m ²)	CI (l/min/m ²)	PCW (mmHg)	PAP (mmHg)	LVEDP (mmHg)
2	20% (43d)	51% (43d)	43	23	3.44	6	23/10	10
	28% (5m)	48% (5m)	50	24	2.75	7	24/10	8
3	36% (34d)	35% (34d)	102	67	3.46	14	33/11	14
	27% (14m)	34% (14m)	135	88	2.66	22	42/10	28
5	patent g. 63% (37d)	58% (1m)	81	34	—	—	—	—
7	patent g. 77% (45d)	51% (1m)	68	33	2.98	8	24/10	12
8	66% (3w)	52% (3w)	79	34	3.00	5	14/7	—

Abbreviations. LMCA, left main coronary artery; EDVI, end-diastolic volume index; ESVI, end-systolic volume index; CI, cardiac index; PCW, pulmonary capillary wedge pressure; PAP, pulmonary artery pressure; LVEDP, left ventricular end-diastolic pressure; g, graft; d, days; w, weeks.

these 5 patients was $36 \pm 35\%$ (range: 7–89%). Overall, reperfusion was achieved in all 7 patients with angiographic occlusion by thrombolysis alone, thrombolysis followed by PTCA, or primary PTCA. The final grade of residual stenosis after reperfusion was $42 \pm 30\%$ in these 7 patients and the duration from onset to reperfusion was 210 ± 77 min. Coronary artery bypass grafting was performed as an emergency procedure in 2 patients because of high-grade residual stenosis of the left main coronary artery.

Acute death due to pump failure occurred in the catheterization laboratory in 2 of the 7 patients who underwent reperfusion therapy.

In both cases, the systolic blood pressure was ≤ 50 mmHg.

Intraaortic balloon counterpulsation was performed in all 8 patients. The hemodynamic state reached Forrester subset I in 4 patients and subset II in 1, while it remained in subset IV in 1 patient. The other 2 patients were thought to have been in subset IV, because they died acutely of pump failure in the catheterization laboratory.

Late Mortality and PredischARGE Angiographic and Hemodynamic Findings

One patient died of congestive heart failure on the 42nd hospital day. The predis-

charge angiographic and hemodynamic findings of the 5 survivors are summarized in Table IV. Among the 3 survivors treated with PTCA, residual stenosis of the left main coronary artery was $\leq 50\%$ in 2 cases (28% and 27%, respectively). In the 2 patients who received emergency coronary artery bypass grafting after PTCA or intracoronary thrombolysis, residual left main coronary artery stenosis was 63% and 77%, respectively. The left ventricular global ejection fraction was $\geq 50\%$ in 4 of the 5 survivors, but it was low (34%) in the other patient. Left ventricular volume increased in 1 patient. The hemodynamic state was Forrester subset I in all 5 survivors.

DISCUSSION

The main finding of this study was that although reperfusion was achieved in all 7 patients by thrombolysis alone, thrombolysis followed by PTCA or primary PTCA, the grade of residual stenosis was relatively high ($42 \pm 30\%$ luminal reduction). As a consequence, 2 patients required urgent emergency coronary artery bypass grafting, while acute death occurred in 2 cases and late death occurred in 1 case, resulting in a mortality rate of 43%. All 5 survivors had a well-developed right coronary artery and good collaterals were noted in 3 cases.

Only 4 of the 8 patients has ST segment elevation in the precordial leads and/or leads I and aVL, indicating acute anterior and/or lateral infarction. Although acute left main coronary artery obstruction generally produces signs of extensive anterior infarction on the electrocardiogram⁸⁻¹⁰ ST segment elevation is not observed in some cases.^{11,12} In our series, ST depression was observed in the precordial leads of 4 patients and depression was observed in leads II, III, and/or aVF of all 8. Therefore, widespread ST depression in both the precordial and inferior leads in association with poor hemodynamics, as well as ST elevation in the precordial leads, are indicators of acute myocardial infarction associated with left main coronary artery obstruction. Variations in left coronary artery distribution and dominance, as well as in the extent of the collateral circulation, would account for the different electrocardiographic findings.

Reperfusion was achieved in all 7 patients in whom it was attempted by thrombolysis alone, thrombolysis followed by PTCA, or primary PTCA. Because of extensive ventricular ischemia, reperfusion must be achieved rapidly in such patients. Therefore, intracoronary thrombolysis was performed during preparation for PTCA. The intracoronary thrombolysis regimen used in this study ("brief and low-dose thrombolysis") achieved reperfusion in 2 of the 5 patients with persistent occlusion. Therefore, thrombolysis alone did not achieve a satisfactory reperfusion rate, at least within a short time, because thrombolysis usually requires 30-40 min to be effective.¹³ Moreover, although there have been reports which have included a survivor after acute left main coronary artery obstruction was treated by thrombolysis^{9,14} a recent study demonstrated that thrombolysis did not reduce mortality in patients who had acute myocardial infarction with cardiogenic shock.³ Our present results, together with those of the earlier study,³ indicate that thrombolysis is an inadequate reperfusion strategy in patients with left main coronary artery obstruction, which is a situation in which rapid reperfusion is mandatory.

Reperfusion was successful in all 5 patients who underwent PTCA. This result is comparable with that reported by O'Keefe et al,⁷ who stated that 9 out of 10 patients with acute left main coronary artery occlusion were successfully revascularized by PTCA. Evidence has been accumulating that PTCA reduces the mortality of infarct patients who had cardiogenic shock. Bates and Topol¹⁵ reviewed the literature and found 14 reports regarding the use of PTCA for cardiogenic shock associated with acute myocardial infarction. PTCA achieved reperfusion in 73% of the patients and reduced the mortality from 65-80% (following thrombolysis) to 44%.¹⁵ Although this study was carried out retrospectively and had a small number of cases, previous reports^{15,16} and the present study both indicate that PTCA is the best strategy for the treatment of acute left main coronary artery obstruction.

Although PTCA reperfused the acutely occluded left main coronary artery, the grade of residual stenosis was relatively high in some patients. Because the left main coronary artery has a larger diameter than

the other coronary arteries, successful dilation requires a marked reduction in stenosis. Moreover, the lesion is often fragile and unstable in patients with acute occlusion, which may explain the relatively inadequate revascularization of our patients. In patients with insufficient revascularization, emergency coronary artery bypass grafting is necessary.

Among the 7 patients who received reperfusion therapy, acute death occurred in 2 and late death occurred in 1. Only the report of O'Keefe et al⁷ is available for comparison with our results. In their study, 4 out of 10 patients died in the catheterization laboratory and late death occurred in another 2 patients. These results are similar to ours. Both studies indicate that although PTCA is a useful strategy for the initial treatment of acute left main coronary artery occlusion, additional aggressive treatment is also necessary.

Although intraaortic balloon counterpulsation was used to assist the heart in all 8 patients, 2 of the patients died acutely of pump failure. In the face of profound myocardial damage and refractory shock, reperfusion cannot rapidly restore severely depressed ventricular function.¹⁷ Our study and previous studies indicate that intraaortic balloon counterpulsation is also not sufficient to control pump failure in some patients with left main coronary artery obstruction. Thus, for treatment of acute left main coronary artery obstruction associated with severe pump failure, more aggressive procedures may be necessary. Recently, some reports^{18,19} have demonstrated that percutaneous cardiopulmonary support is more effective than intra-aortic balloon counterpulsation. Unfortunately, a percutaneous cardiopulmonary support device was not available when these patients were admitted.

The right coronary artery was well developed in all 5 survivors and good collaterals were also observed in 3 patients. In previous case reports, the right coronary artery was dominant in 18 of 19 survivors,²⁰ indicating that right coronary dominance is essential for survival in this situation. Previous reports also reveal that 8 out of 18 patients had collateral circulation and that 2 patients without collaterals died.²⁰ Thus, good collateral circulation appears to be another factor related to survival.

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