Factors Predicting Mortality in Patients after Myocardial Infarction Caused by Left Main Coronary Artery Occlusion

Significance of ST Segment Elevation in Both aVR and aVL Leads

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SUMMARY
Acute left main coronary artery obstruction is rare and most patients in this clinical setting die of sudden death or cardiogenic shock. During the past 8 years, we encountered 13 patients with acute myocardial infarction caused by total occlusion of the left main coronary artery (LMCA-AMI). Thus, we surveyed these patients, and attempted to elucidate helpful predictors related to the prognosis. Six of 13 patients with LMCA-AMI survived. Successful left coronary artery dilatation was achieved in all survivors (group S), and in 5 (71%) non-survivors (group non-S). The age was not different between the two groups. A past history of angina was confirmed in 83% of group S, while only in 29% of group non-S. Clinical findings such as time of onset of AMI, interval from the AMI onset to admission, elapsed period from the AMI onset to recanalization of LMCA and the value of CK on admission were not different between the two groups. However, cardiogenic shock occurred in only 1 patient (17%) in group S compared with 5 patients (71%) in group non-S. As emphasized in the literature, good collateral circulation to the left anterior descending artery was observed in 5 patients (83%) in group S, while not observed in group non-S. Electrocardiographically, ST elevation in the aVR lead was very characteristic. This finding was confirmed in 69% of the total patients. Noticeably, 5 out of 6 non-survivors (83%) showed ST elevation not only in leads aVR but also in the aVL lead. In addition to the absence of collateral circulation, this electrocardiographic finding, which obviously indicates the presence of extensive myocardial ischemia in the diseased heart, is a simple and important predictor suggesting a poor prognosis in LMCA-AMI patients. (Jpn Heart J 2000; 41: 571-581)

Key words: Total occlusion of the left main coronary artery, Acute myocardial infarction, Prognosis, ST elevation in aVR and aVL leads

Due to the increasing development of cardiac emergency systems including the Coronary Care Unit (CCU) and also early revascularization therapy such as per-
cutaneous transluminal coronary angioplasty (PTCA) in the acute phase, the mortality for acute myocardial infarction has steadily declined to approximately 10 percent or less in recent years.\(^1\) Recently, percutaneous inserted cardiopulmonary support (PCPS) has been used as adjunctive therapy in high-risk patients undergoing PTCA. However, cardiogenic shock resulting from acute myocardial infarction is still a serious complication with a high mortality rate. Most patients with acute myocardial infarction caused by left main coronary artery occlusion (LMCA-AMI) in particular rapidly fall into cardiogenic shock or die suddenly. Although stenting of the unprotected left main coronary artery has been attempted as a therapeutic option in patients with very high surgical risks or severe comorbid conditions, little information is available about the clinical outcome. Moreover, identifying patients at high risk of death from cardiogenic shock among patients with LMCA-AMI is of interest. Therefore, in the present study we surveyed our own LMCA-AMI patients and attempted to elucidate helpful factors closely related to the prognosis of the patients.

**METHODS**

From January 1990 to May 1997, 655 patients with acute myocardial infarction and/or unstable angina were admitted to Kitasato University Hospital and underwent emergent cardiac catheterization. Of these 655 patients, 13 patients had angiographically documented acute occlusion of the left main coronary artery. None underwent previous coronary bypass surgery or coronary angioplasty. The past history, patient characteristics, therapeutic strategy and electrocardiographic findings of these 13 patients were retrospectively investigated. Myocardial infarction was diagnosed by 1) chest discomfort consistent with myocardial ischemia; 2) electrocardiogram demonstrating ST segment elevation $\geq 1$mm and 3) elevation of total creatine kinase (CK) during hospitalization. Cardiogenic shock was diagnosed when all of the following criteria were met: 1) systolic arterial pressure $< 90$ mmHg without inotropic agents or intraaortic balloon pump (IABP) support; 2) persistent oliguria (urine flow of less than 30 ml/h) and 3) acute pulmonary congestion ($\geq$ Killip class II).

All patients were angiographically investigated as quickly as was possible after history taking and physical and laboratory examinations. ECG and UCG tests were repeated close to the time of the examinations. Arterial patency, defined as TIMI grade (Thrombolysis in Myocardial Infarction grade) in the infarct related coronary artery, was assessed by coronary angiography. The collateral flow was graded according to Rentrop, et al.\(^2\) All cardiac catheterization was performed by the Judkins technique.
clarify prognostic factors, we followed up the patients until discharge from the hospital. Based on results until the discharge, we divided them into two groups: survivors and non-survivors, and compared both groups from the lead clinical aspects such as patient characteristics, clinical features on admission, coronary angiogram, treatment and electrocardiographic findings. Data are expressed as mean ± SD. Differences between the two groups were assessed by the unpaired two-tailed t test. Statistical significance was defined as \( p < 0.05 \).

**RESULTS**

**Patient characteristics:** Patient characteristics are shown in Table I. There were 9 male and 4 female patients. Six of the 13 patients with LMCA-AMI survived. The ages of the patients were not different between the two groups (Group S: mean 58 ± 13, Group non-S: mean 57 ± 13). The number of patients with prior anginal pain in group S showed a tendency to be higher than that in group non-S, but was not statistically significant. There were no differences between the two groups with respect to coronary risk factors such as hypertension, hypercholesterolemia, smoking and diabetes mellitus.

**Clinical features on admission (Table II):** Concerning the time of onset of the 13 patients with LMCA-AMI, 10 (77%) were in the morning, 2 in the (15%) afternoon, and 1 (8%) at midnight. The mean time from the onset of symptoms suggestive of AMI to admission was 160 ± 77 min in group S and 159 ± 76 min in group non-S (\( p = \text{ns} \)). Cardiogenic shock occurred in only one patient (17%) in group S but in 5 patients (71%) in group non-S (\( p < 0.01 \)). The elapsed time between the onset of AMI and the opening of LMCA (reperfusion) was 273 ± 89 min in group S and

<table>
<thead>
<tr>
<th>Male / female</th>
<th>Group S (n = 6)</th>
<th>Group non-S (n = 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>58</td>
<td>57</td>
</tr>
<tr>
<td>History of angina</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Hypertension</td>
<td>3</td>
<td>2</td>
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<tr>
<td>Hypercholesterolemia</td>
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<td>3</td>
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<tr>
<td>Smoking</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>3</td>
<td>1</td>
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*group S = survivors; group non-S = non-survivors.*
271 ± 84 min in group non-S (p = ns). The value of CK on admission was 338 IU /l in group S and 379 IU /l in group non-S (p = ns).

**Coronary angiogram (Figure 1):** Complete total occlusion of LMCA was observed in 4 patients in each group by coronary angiogram. Collateral circulation to the left coronary system was observed in all patients in group S, but in only 3 (43%) in group non-S. Moreover, good collateral circulation (Rentrop 3) to the left anterior descending artery (LAD) was observed in 5 patients (83%) in group S, but was not observed in group non-S. In group non-S, poor collateral circulation (Rentrop 1) to LAD was observed in only one patient (14%).
Treatment after admission: IABP was employed in 12 patients (92%). Percutaneous cardiopulmonary support (PCPS) was used in 3 patients with cardiogenic shock, but all 3 patients died. In group S (6 survivors), direct PTCA was performed in 4 patients, and in the other 2 patients, rescue PTCA after intracoronary thrombolysis (ICT) was performed, since anterograde flow of TIMI grade III was not achieved. Of the 4 patients who underwent primary PTCA, intracoronary stent implantation was performed in two patients and one patient was given ICT because of failed PTCA. Finally, in group S, successful left coronary artery dilatation was achieved in all patients (100%). Elective coronary artery bypass grafting (CABG) was performed in 2 patients in group S. Of the 7 patients in the non-S group, direct PTCA was performed in 6 patients, and rescue PTCA after ICT was performed in 1 patient. Among the 6 patients who underwent direct PTCA, 3 patients had stent implantation because of intimal dissection and/or a suboptimal result due to high-grade residual stenosis. Overall, in the non-S group, successful left coronary artery dilatation was achieved in 5 of 7 patients (71%). The other 2 patients experienced unsuccessful recanalization and died of cardiogenic shock within a few hours.

Electrocardiographic findings (Table III): 1) Limb leads; ST segment elevation was present in the I, aVL and aVR leads in 67%, 67%, and 50% in group S, and in 50%, 83%, and 100% in group non-S, except one case with ventricular fibrillation (VF), respectively. Moreover, ST segment elevation was present in both I and aVR leads in 17% in group S and 50%
in group non-S, in aVR and aVL leads in 17% in group S and 83% in group non-S ($p > 0.05$), and in leads I and aVL leads in 67% in group S and 50% in group non-S, respectively. On the other hand, ST segment depression in all three leads (II, III and aVF) was common. This finding was present in 11 patients except the one with VF.

2) Precordial leads; ST segment elevation in precordial leads was present in 4 patients in each group and ST segment depression was present in 3 patients in each group. The QRS width on admission was wider in the non-S group (117 msec) than that in the S group (93 msec).

**DISCUSSION**

**History of patients:** Group S had a greater prevalence of previous angina than did group non-S (5 patients [83%] vs 2 patients [29%]). Prior angina pectoris may explain the well-developed collateral circulation to the left coronary system in group S. Good collateral circulation will contribute to prevent cardiogenic shock.

**Clinical features on admission:** A higher incidence concerning the time of onset of acute myocardial infarction has been reported in the morning with a peak in the first 3h after awakening. Our study patients also had a morning peak in the onset of myocardial infarction. The time from the onset of symptom suggestive of AMI to admission was less than 5 hours. This shorter time to admission may reflect the fear of this disease. In short, many patients with LMCA-AMI may die before reaching medical care. Nakano experienced one case with left main coronary artery disease who died suddenly during ambulatory Holter monitoring and speculated that the mechanism of sudden death might be a combination of ventricular fibrillation or bradyarrhythmia and electromechanical dissociation secondary to sudden onset of severe pump failure. The incidence of cardiogenic shock complicating AMI was 7.5 percent. Page, *et al.* studied 20 patients with cardiogenic shock and found all patients exhibited necrosis of $\geq 40\%$ of the left ventricular myocardium. Kalbfleisch reported that the left coronary artery supplies about two-thirds of the entire ventricular myocardium. This is the reason why left ventricular myocardial blood supply is mainly delivered from the LCA and sudden occlusion of LMCA is usually followed by a rapid deterioration of left ventricular function. In his study, Quigley demonstrated that a combination of severe left main stenosis and an acute anterolateral infarction was associated with cardiogenic shock in 47 percent of his patients. In our case, 6 of 13 patients (46%) were admitted with cardiogenic shock. Recently, aggressive intervention
has been recommended for patients in cardiogenic shock. Bengtson, et al. reported patency of the infarct-related artery was most closely associated with in-hospital and long-term mortality. Moreover, Moosvi, et al. reported that early revascularization, particularly within 24 hours from the onset of cardiogenic shock, improved survival in patients with cardiogenic shock complicating acute myocardial infarction. However, of 4 patients with cardiogenic shock who had successful angioplasty within 6 hours, 3 patients (75%) died during hospitalization. Overall, 5 of 6 patients (86%) with cardiogenic shock died during hospitalization. This result is in agreement with a previous report that patients with left main shock syndrome have a grave prognosis regardless of various types of management.

Coronary angiogram: Most surviving patients angiographically demonstrate good coronary collaterals originating from the right coronary artery and perfusing the distal field of the left coronary system as shown in Figure 1. This angiostructure seemed to be the most important factor for surviving this disease. Our results were consistent with previous reports.

Content of Treatment: Intraaortic balloon counterpulsation in patients with cardiogenic shock frequently has improved hemodynamic status without affecting survival. Recently, PCPS has been used as adjunctive therapy in high-risk patients undergoing PTCA. However, Tommaso, et al. reported that the addition of PCPS to balloon angioplasty does not alter the outcome of patients with left main coronary stenosis. We attempted PCPS-supported angioplasty in 3 patients with cardiogenic shock complicating LMCA-AMI, but all patients who underwent PCPS died because of cardiogenic shock.

Balloon angioplasty of unprotected LMCA stenosis carries a high procedural mortality rate and poor long-term results. Procedural death was usually the result of acute coronary occlusion due to intimal dissection and thrombosis. Moreover, the high rate of restenosis after balloon angioplasty was a major factor in the poor prognosis of patients with LMCA disease. The presence of a high content of elastic fibers in the proximal segment of the LMCA has been proposed as the possible mechanism of elastic recoil and the high restenosis rate of conventional PTCA at this site. Therefore, coronary artery bypass surgery has been the standard treatment for significant LMCA disease. However, recently some reports have begun to appear in the literature concerning stenting of unprotected LMCA disease in patients with very high surgical risks or severe comorbid conditions. For this reason, this technique has been shown to be highly effective in preventing elastic recoil and abrupt vessel closure, thereby improving the acute result of PTCA. In our study, stent implan-
tation was performed in 5 patients and successful left coronary artery dilatation was achieved in all patients. However, only two patients without cardiogenic shock survived. This result is in agreement with a previous report. An important observation from our study is the poor outcome of patients with left main coronary artery occlusion with cardiogenic shock despite the use of stents and PCPS support. Therefore, emergent coronary stenting in the LMCA may have allowed the patient to achieve and maintain a good hemodynamic status as a bridge to emergency surgical revascularization at the moment. Further clinical studies with larger numbers of patients will be needed to evaluate the late outcome after stenting of LMCA disease.

**Electrocardiographic findings:** Although acute LMCA occlusion showed signs of extensive anterior infarction on the electrocardiogram, ST segment elevation was not observed in all cases. Iwasaki, *et al.* reported that widespread ST depression in both precordial and inferior leads, as well as ST elevation in the precordial leads, were indicators of LMCA occlusion. In our case, time of onset, variation of the left coronary tree, and the extent of the collateral circulation might have affected the variable electrocardiographic findings. ST segment depression in inferior leads (II, III and aVF) was very common. This is consistent with previous reports. ST segment depression in inferior leads in patients with LMCA occlusion may represent reciprocal changes of the injury current from the basal anterior septum as well as the injury current arising for the basal antero-lateral region. ST segment elevation in lateral leads (I and aVL) was also common. This finding is persuasive, because acute LMCA occlusion showed signs of extensive anterior infarction including the region perfused by the diagonal branch. ST segment elevation in the aVR lead, which is usually overlooked even in unstable angina caused from three-vessel disease or LMCA disease, has previously been described. Engelen reported the aVR lead was very useful for identifying LAD occlusion proximal to the first major septal perforator. In fact, ST segment elevation in the aVR lead was found in 9 patients (69%) in our study. This electrographic finding is probably the result of transmural ischemia of the basal part of the septum. For this reason, they found that none of the 10 patients with LAD occlusion proximal to the first diagonal branch but distal to the first septal perforator showed ST segment elevation in the aVR lead. Moreover, 5 of the non-survivors (83% except one VF patient) showed ST segment elevation in both the aVR and aVL leads. Figure 2 shows typical findings of ST segment elevation in the aVR and aVL leads. In our study, collateral circulation to the LAD was not observed in patients with these find-
ings. This electrocardiographic finding, which obviously indicates the presence of extensive myocardial ischemia in the diseased heart, is a simple and important predictor suggesting a poor prognosis for the LMCA-AMI patient.

**Conclusion:** As previously reported, LMCA-AMI with cardiogenic shock leads to a grave prognosis in spite of various management techniques. Our

![Figure 2](image.png)

*Figure 2.* Admission electrocardiogram of a patient in group non-S (Case 13). Typical ST elevation was found in both the aVR and aVL leads.
results indicate the clinical outcome of patients with LMCA-AMI is strongly dependent on the degree of intercoronary collaterals. In electrocardiographic findings, ST segment elevation in both the aVR and aVL leads may reflect widely spreading transmural ischemia, including that of the basal part of the septum. This finding is a useful predictor indicating a poor prognosis.

ACKNOWLEDGMENT

This study was supported by a grant from the Academic Frontier Project of the Japanese Ministry of Education, Science, Sports and Culture.

REFERENCES


