Clinical Features and Outcomes of Primary Percutaneous Intervention in Acute Myocardial Infarction Involving the Left Main Coronary Artery

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Abstract

Background: Acute myocardial infarction (AMI) due to left main coronary artery (LMCA) occlusion is rare but has high mortality and morbidity rates. A previous series reporting on the outcome of acute LMCA occlusion also indicated a poor prognosis. However, some of the previous studies were conducted in the era of bare mental stents and lack of mechanical circulation support.

Objectives: In this study, we aimed to analyze the outcomes of primary percutaneous intervention (PCI) in patients with AMI involving the LMCA.

Methods: This retrospective, single-center, observational study included a total of 21 patients with AMI who underwent primary percutaneous intervention (PCI) over the LMCA. We collected data from August 2014 to August 2022 and recorded the critical condition, lesion characteristics, morbidity and mortality.

Results: Compared with patients who survived to discharge, those who died during admission had a higher percentage of stenosis and lower final Thrombolysis in Myocardial Infarction flow, were more likely to require hemodialysis, and were less likely to undergo coronary stenting.

Conclusions: Percutaneous revascularization of acute LMCA occlusion via stenting is practical and safe. However, the limited sample size of our study is a significant limitation, so additional research is necessary to support our findings.

Keywords: acute myocardial infarction, left main coronary artery occlusion

Introduction

Acute myocardial infarction (AMI) involving left main coronary artery (LMCA) occlusion is rare, with a previous series reporting a mortality rate of 4-7%,[1-3] which is higher than that of other coronary artery occlusions. In patients with stable angina with unprotected LMCA stenosis, coronary artery bypass grafting (CABG) has been the standard treatment and is recommended as a Class I indication by the American College of Cardiology/American Heart Association (2021)

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and European Society of Cardiology (2020) guidelines. However, limited data are available on clinical outcomes after primary percutaneous intervention (PCI) in patients presenting with AMI with unprotected LMCA as the infarct-related coronary artery; in addition, some of these reports are from the era of bare mental stents, in the absence of mechanical thrombectomy devices, or even without mechanical circulation support. Therefore, in this single-center study, we aimed to analyze the outcomes of primary PCI in patients with AMI involving the LMCA.

Methods

Patient population

Between August 2014 and August 2022, a total of 1,764 patients with AMI underwent primary percutaneous coronary angioplasty (PTCA) in our department. Of these, 35 (1.98%) patients had a totally occluded LMCA or severe stenosis. Fourteen of these 35 patients with LMCA underwent emergency bypass surgery instead of PTCA and were excluded from this study. Ultimately, 21 patients were included in the study. Data on demographics, clinical features and outcomes were collected from all in-hospital and clinical records. One sub-investigator, who was blinded to the study outcome, assessed the angiographic features. The diagnosis of AMI required the presence of two of the following three criteria: (1) a characteristic clinical history, (2) serial changes on ECG suggesting infarction (Q-waves) or injury/ischemia (ST-segment elevation and/or depression) and (3) an increase in the Troponin I/hs-Troponin I level to more than double the normal laboratory value.

Statistics

Categorical variables (e.g., sex) were summarized and presented as frequencies and percentages. Continuous variables (e.g., age) were summarized and expressed as mean ± standard deviation. The clinical characteristics of patients who survived to discharge versus those who died during admission were compared using Fisher's exact test for categorical variables and independent sample t-test for continuous variables. All tests were two-tailed, and $P < 0.05$ was considered statistically significant. Due to the small sample size of this study, $P < 0.1$ was considered borderline statistically significant. Data analyses were conducted using SPSS version 26 (IBM SPSS Inc., Chicago, Illinois, USA).

Results

Table 1 details the individual data for the 21 patients. The selected clinical characteristics were age, sex, ventricular tachycardia (VT) or ventricular fibrillation (VF), Killip classification, ventilator use, mechanical circulation support, obstructive level, percentage of stenosis, status of collateral flow, door to balloon (D2B) time, initial Thrombolysis in Myocardial Infarction (TIMI) flow, final TIMI flow, reperfusion methods, procedural success or failure, hemodialysis, length of stay and 30-day mortality or in-hospital death.

Table 2 summarizes the clinical characteristics of the 21 patients. The mean age was 69.1 years, and two-thirds (n = 14) of the patients were male. Eight patients (38%) had VT/VF episodes, 11 (52%) had Killip classification IV, 13 (62%) had ventilator use, and 17 (81%) required mechanical circulation support. Four patients (19%) had obstruction of the ostium and two (10%) had proximal obstruction. The average percentage of stenosis was 93.4%, and six patients (29%) had no collateral flow. The mean D2B time was 64.4 min. The distribution of reperfusion methods was as follows: 13 patients (62%) underwent coronary stenting, seven (33%) underwent balloon/CABG, and one (5%) received balloon angioplasty alone. Approximately half of the patients (n = 10, 48%) underwent hemodialysis during admission.

The results showed that the following clinical characteristics were significantly different between patients who survived to discharge and those who died during admission: percentage of stenosis, final TIMI flow, reperfusion method and

Table 1. Clinical characteristics of the 21 patients

Patient No.	Age	Sex	VT/VF	Killip class	Ventilator	MCS	Obstructive level[a]	Stenosis, %	Collateral flow[b]	D2B time	Initial TIMI flow	Final TIMI flow	Reperfusion	Procedural success	HD	LOS	30d death
1	72	Male	No	3	Yes	Yes	O	100	1	79	1	3	Stenting	Yes	Yes	35	No
2	67	Female	Yes	4	Yes	Yes	M	85	2	100	0	1	Balloon/CABG	Yes	Yes	59	No
3	82	Male	No	1	No	Yes	P	92	0	86	0	3	Stenting	Yes	Yes	72	Yes
4	74	Female	Yes	3	No	Yes	D	100	0	35	1	3	Stenting	Yes	No	40	No
5	63	Male	No	4	Yes	Yes	M	94	1	55	1	3	Stenting	Yes	No	6	No
6	55	Male	Yes	4	Yes	Yes	O	100	0	69	0	2	Balloon/CABG	Yes	Yes	3	Yes
7	69	Male	No	2	No	No	M	86	0	45	1	3	Stenting	Yes	No	10	No
8	61	Male	No	1	No	No	D	83	2	57	1	3	Stenting	Yes	No	7	No
9	85	Female	Yes	4	Yes	Yes	O	100	0	110	0	1	Balloon/CABG	No	No	1	Yes
10	77	Male	No	3	Yes	Yes	M	90	1	82	3	3	Stenting	Yes	No	5	No
11	52	Male	Yes	4	Yes	Yes	O	100	1	32	0	2	Balloon/CABG	Yes	Yes	42	No
12	67	Male	No	3	No	Yes	D	92	1	53	3	3	Stenting	Yes	No	13	No
13	75	Female	No	4	No	Yes	D	90	1	66	2	3	Stenting	Yes	No	22	No
14	48	Male	Yes	4	Yes	Yes	M	90	0	72	1	2	Balloon/CABG	Yes	Yes	50	Yes
15	73	Female	No	2	Yes	No	M	92	2	53	3	3	Stenting	Yes	No	33	No
16	68	Male	No	3	No	Yes	D	89	1	69	3	3	Stenting	Yes	No	6	No
17	73	Male	No	3	No	No	D	91	2	47	3	3	Stenting	Yes	No	7	No
18	65	Male	No	4	Yes	Yes	D	90	2	34	2	3	Stenting	Yes	Yes	47	No
19	86	Female	No	4	Yes	Yes	D	100	1	102	0	1	Balloon	No	Yes	53	Yes
20	66	Male	Yes	4	Yes	Yes	M	99	1	22	1	2	Balloon/CABG	Yes	Yes	82	Yes
21	74	Female	Yes	4	Yes	Yes	P	98	1	85	0	3	Balloon/CABG	Yes	Yes	5	Yes

Abbreviation: VT, ventricular tachycardia; VF, ventricular fibrillation; MCS, mechanical circulation support; D2B, door-to-balloon; TIMI, Thrombolysis in Myocardial Infarction; HD, hemodialysis; LOS, length of stay; 30d death, mortality in hospital/30d; CABG, coronary artery bypass graft;

[a] O=ostial; P=proximal; M=middle; D=distal;

[b] 0=No collateral flow; 1=Partial collateral flow to the ischemic site; 2=Full collateral flow to the site of occlusion.

Table 2. Clinical characteristics of the 21 patients by the survival status to discharge

Variable	Total (*n* = 21)	Mortality in hospital/30d Yes (*n* = 7)	Mortality in hospital/30d No (*n* = 14)	*P* value
Age, year	69.1 ± 9.9	70.9 ± 15.1	68.3 ± 6.6	0.588
Male sex	14 (66.7)	4 (57.1)	10 (71.4)	0.638
VT/VF	8 (38.1)	5 (71.4)	3 (21.4)	0.056
Killip classification				0.066
1	2 (9.5)	1 (14.3)	1 (7.1)	
2	2 (9.5)	0 (0.0)	2 (14.3)	
3	6 (28.6)	0 (0.0)	6 (42.9)	
4	11 (52.4)	6 (85.7)	5 (35.7)	
Ventilator use	13 (61.9)	6 (85.7)	7 (50.0)	0.174
Mechanical circulation support	17 (81.0)	7 (100.0)	10 (71.4)	0.255
Obstructive level				0.097
Ostial	4 (19.0)	2 (28.6)	2 (14.3)	
Proximal	2 (9.5)	2 (28.6)	0 (0.0)	
Middle	7 (33.3)	2 (28.6)	5 (35.7)	
Distal	8 (38.1)	1 (14.3)	7 (50.0)	
Stenosis, %	93.4 ± 5.6	97.0 ± 4.2	91.6 ± 5.4	0.032
Collateral flow				0.081
No collateral flow	6 (28.6)	4 (57.1)	2 (14.3)	
Partial collateral flow to the ischemic site	10 (47.6)	3 (42.9)	7 (50.0)	
Full collateral flow to the site of occlusion	5 (23.8)	0 (0.0)	5 (35.7)	
D2B time, min	64.4 ± 24.5	78.0 ± 28.8	57.6 ± 19.8	0.071
Initial TIMI flow				0.053
0	7 (33.3)	5 (71.4)	2 (14.3)	
1	7 (33.3)	2 (28.6)	5 (35.7)	
2	2 (9.5)	0 (0.0)	2 (14.3)	
3	5 (23.8)	0 (0.0)	5 (35.7)	
Final TIMI flow				0.029
1	3 (14.3)	2 (28.6)	1 (7.1)	
2	4 (19.0)	3 (42.9)	1 (7.1)	
3	14 (66.7)	2 (28.6)	12 (85.7)	
Reperfusion				0.003
Stenting	13 (61.9)	1 (14.3)	12 (85.7)	
Balloon/CABG	7 (33.3)	5 (71.4)	2 (14.3)	
Balloon	1 (4.8)	1 (14.3)	0 (0.0)	
Procedural success	19 (90.5)	5 (71.4)	14 (100.0)	0.100
Hemodialysis	10 (47.6)	6 (85.7)	4 (28.6)	0.024
LOS, day	28.5 ± 25.0	38.0 ± 34.5	23.7 ± 18.5	0.227

Abbreviation: VT, ventricular tachycardia; VF, ventricular fibrillation; MCS, mechanical circulation support; D2B, door-to-balloon; TIMI, Thrombolysis in Myocardial Infarction; HD, hemodialysis; LOS, length of stay; 30d death, mortality in hospital/30d; CABG, coronary artery bypass graft.

Figure 1a. Coronary angiograms of case no. 13 with partial collateral flow to the ischemic site.

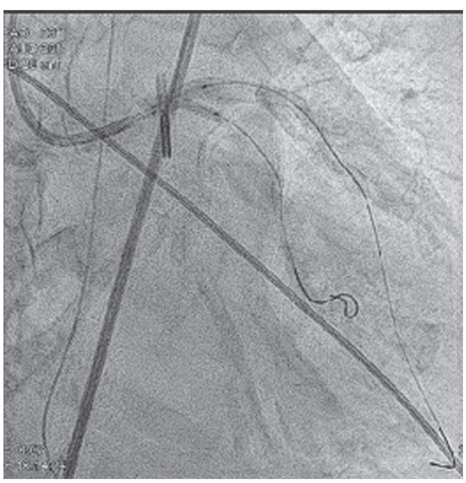

Figure 1b. After setting IABP, the primary PCI with stenting was performed.

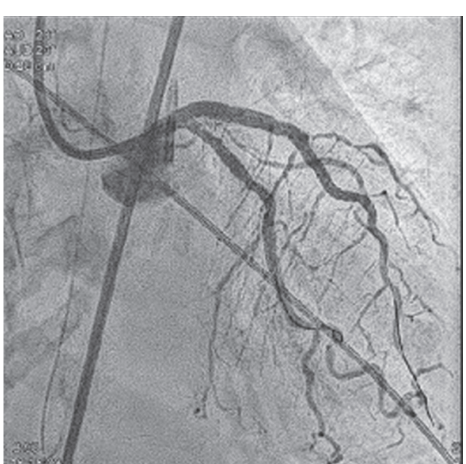

Figure 1c. The TIMI 3 flow restore after stenting.

hemodialysis ($P < 0.05$). Compared with patients who survived to discharge, those who died during admission had a higher percentage of stenosis, had lower final TIMI flow, were less likely to undergo coronary stenting, and were more likely to undergo hemodialysis. VT/VF, Killip classification, obstructive level, collateral flow, D2B time and initial TIMI flow showed borderline significant differences between the groups ($P < 0.1$).

Discussion

No trials have compared the outcomes of CABG and PCI in AMI due to LMCA. However, based on a previously published study, the outcomes of both revascularizations were poor. Nakanishi et al.[1] reported that the operative mortality was 46%, whereas Quigley et al.[2] and Chauhan et al.[3] reported high in-hospital mortality rates of 83% and 94%, respectively. However, most of the patients in the study by Quigley et al. had been admitted to hospital for over 12 h after AMI, and most of those in Chauhan et al.'s series had an occluded RCA. Therefore, the high mortality rates in their studies could be attributed to late revascularization or the absence of intercoronary collaterals. A later study,[4] which reported an in-hospital mortality rate of 44%, attempted drug-eluting stent implantation. In our series, the mortality rate was 33.3%, which was better than that reported in these previous studies. This may have been because we established a comprehensive system to support the heart team to shorten the D2B time, and provided early and aggressive management to maintain hemodynamic status using mechanical circulation support. Highly potent antiplatelet and anticoagulant agents also contributed to the successful reperfusion and survival rates.

Although LMCA occlusion or severe stenosis is a Class I indication for CABG, the majority of our patients underwent PCI rather than bypass surgery. The first reason was that there was insufficient time for emergent CABG in this stormy clinical presentation. Some of our patients underwent coronary artery angiography even during cardiopulmonary cerebral resuscitation, and rapid restoration of coronary flow was the first priority. Second, most of these patients refused to undergo surgical revascularization because of potential risks, anesthetic concerns and comorbidities such as diabetes mellitus, renal insufficiency, etc.

In addition, we found that patients who underwent stenting had better clinical outcomes (survived vs. died: 86% vs. 14%). A hybrid approach of initial revascularization by percutaneous old balloon angioplasty and elective/emergent surgery had an unfavorable prognosis (survived vs. died: 14% vs. 71%). One likely explanation was that while early coronary reperfusion is crucial for prognosis, surgical revascularization is more time-consuming than percutaneous revascularization with stenting. Another interpretation of the result is that those who receive rescue bypass surgery may be doing so due to failure of percutaneous revascularization. However, larger studies should be performed to confirm our findings.

Some published series[4-7] have demonstrated that LMCA AMI survivors are more likely to have avoided cardiogenic shock, experienced effective reperfusion, and have collaterals to the left coronary artery. However, these results do not agree with those of our series. Patients with Killip IV classification and absence of collateral flow indeed have a higher mortality rate; however, the statistical differences are borderline ($P = 0.066$ and 0.081, respectively). It may be reasonable to assume that the practice has changed with improved PCI techniques, mechanical assist devices, use of thrombosuction equipment and newer antiplatelet therapy, all of which could improve the prognosis even under catastrophic shock and no collateral coronary flow.

In our study, a high degree of LMCA stenosis could determine the survival, and was statistically significant. We speculate that this is because of the limited population size; however, the high percentage of stenosis or total occlusion will result in poor outcomes.

Finally, dialysis patients with AMI have dismal long-term survival rates,[8] and our study demonstrated that patients who need to receive hemodialysis during hospitalization have a much higher mortality rate. One possible explanation for the relationship between low eGFR and in-hospital outcomes among the LMCA AMI patients is “cardiorenal syndrome”. Cardiorenal syndromes, in which the coexistence of heart failure and renal disorder causes pathological interactions, thereby have synergistic adverse effects on mortality.

Conclusions

The present study provides evidence that a high percentage of stenosis, lower final TIMI 0 flow, reperfusion methods without stenting and hemodialysis are independent determinants of poor prognosis among patients with left LMCA AMI undergoing primary PCI. Our findings suggest that primary LMCA PCI with stenting is practical and safe. However, a major drawback of our study is the small sample size; therefore, further research is warranted to confirm our findings.

Abbreviations

AMI: acute myocardial infarction; CABG: coronary artery bypass grafting; D2B: door to balloon; LMCA: left main coronary artery; PCI: percutaneous intervention; PTCA: percutaneous coronary angioplasty; TIMI: Thrombolysis in Myocardial Infarction; VT: ventricular tachycardia; VF: ventricular fibrillation.

Declaration of Conflict of Interest

All authors declare no conflict of interest.

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