ORIGINAL ARTICLE

Emergency Percutaneous Coronary Intervention in Unprotected Left Main Coronary Arteries. Predictors of Mortality and Impact of Cardiogenic Shock

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Introduction and objectives. Percutaneous coronary intervention (PCI) for unprotected left main coronary artery (LMCA) disease may be essential following acute myocardial infarction (AMI). However, few data are available on the use of emergency PCI in unprotected LMCAs outside of clinical trials. The objective of this study was to determine the frequency of in-hospital mortality, its predictors, and its association with cardiogenic shock, and long-term outcomes in patients with unprotected LMCA disease who undergo emergency PCI because of AMI.

Methods. The study included 71 consecutive patients who underwent emergency angioplasty of the LMCA and who were followed up clinically.

Results. Overall, 42 patients (59%) had ST-elevation AMI and 47 (66%) had cardiogenic shock or developed it during PCI. Eleven patients (16%) died in the catheterization laboratory and 33 (47%) died during hospitalization. In-hospital mortality was similar in those with and without evidence of ST-segment elevation on ECG (48% vs 45%; *P*=1). Multivariate analysis showed that the predictors of in-hospital mortality were cardiogenic shock (odds ratio [OR] =4.5; 95% confidence interval [CI], 1.1-18) and incomplete revascularization (OR=5.1; 95% CI, 1.0-26). After discharge, 39 patients were followed up for a median of 32 months. Mortality in the first year was 10%.

Conclusions. Emergency PCI is a viable therapeutic option for AMI due to unprotected LMCA disease. However, in-hospital mortality is high, regardless of ST-segment elevation, particularly if there is cardiogenic shock or complete revascularization has not been achieved.

Key words: *Left main coronary artery. Angioplasty. Acute myocardial infarction. Cardiogenic shock.*

Intervencionismo percutáneo urgente sobre el tronco coronario izquierdo no protegido. Factores predictores de mortalidad y análisis del shock cardiogénico

Introducción y objetivos. El intervencionismo coronario percutáneo (ICP) de la enfermedad de tronco coronario izquierdo (TCI) no protegido puede ser necesaria en el infarto agudo de miocardio (IAM). Sin embargo, la evidencia del ICP urgente en el TCI fuera de ensayos clínicos no es muy amplia. El objetivo del estudio es evaluar la mortalidad intrahospitalaria, sus predictores y su asociación con shock, así como eventos a largo plazo en pacientes con enfermedad de TCI tratado con ICP urgente debido a un IAM.

Métodos. Se incluyó a 71 pacientes consecutivos en los que se realizó una angioplastia urgente sobre el TCI y seguimiento clínico posterior.

Resultados. Presentaron IAM con elevación del ST 42 (59%) y presentaban shock cardiogénico o lo desarrollaron durante el procedimiento 47 (66%). Murieron en la sala de hemodinámica 11 (16%) y 33 (47%) durante la hospitalización. La mortalidad intrahospitalaria fue independiente de la elevación del ST en el ECG (el 45 frente al 48%; p = 1). Los predictores multivariables de mortalidad intrahospitalaria fueron el shock cardiogénico (4,5; intervalo de confianza [IC], 1,1-18) y la revascularización incompleta (*odds ratio* [OR] = 5,1; IC del 95%, 1-26). Tras el alta hospitalaria se siguió a 39 pacientes durante una mediana de 32 meses. La mortalidad durante el primer año de seguimiento fue del 10%.

Conclusiones. El ICP es una opción terapéutica en el seno del IAM debido a enfermedad de TCI. Sin embargo, la mortalidad intrahospitalaria es elevada independientemente de la elevación del ST en el ECG y, especialmente, cuando se asocia a shock cardiogénico y no se logra una revascularización completa.

Palabras clave: *Tronco coronario izquierdo. Angioplastia. Infarto agudo de miocardio. Shock cardiogénico.*

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ABBREVIATIONS

AMI: acute myocardial infarction
DES: drug-eluting stent
LMCA: left main coronary artery
PCI: percutaneous coronary intervention

INTRODUCTION

Occlusion of the left main coronary artery (LMCA) is occasionally found in angiographic studies following acute myocardial infarction (AMI) (1.5% of patients).[1,2] When observed, the prognosis is bad unless substantial collateral circulation exists or reperfusion of the causal lesion is immediate.[3-5] When neither option is available, most patients die from ventricular arrhythmias or cardiogenic shock.[6]

Primary angioplasty is the treatment of choice in ST-segment elevation AMI when the conditions pertaining permit intervention.[4,7] Although guidelines indicate surgery as the treatment of choice in LMCA, percutaneous coronary interventions (PCIs) are also recommended in patients with cardiogenic shock following AMI. If surgery is impossible in an emergency and with patients at high surgical risk, PCI and mechanical support are considered the first option for treatment.[8,9] Notwithstanding, few data are available on this situation and patient numbers in published series are low.[2,10-22]

A SHOCK study sub-analysis comparing surgical revascularization with PCI in patients with shock following AMI, found no short- and mid-term differences in mortality.[17] However, a registry constructed in 2001 reported only 4.9% of patients were susceptible to surgery.[18] Improved PCI techniques have now made this a feasible solution for the hemodynamic instability the situation entails.

The primary objective of the present study is to analyze a series of patients with LMCA disease and AMI undergoing emergency PCI and determine in-hospital mortality and its predictors, out-of-hospital mortality, and repeat revascularization. The secondary objective is to determine the short-term mortality associated with cardiogenic shock.

METHODS

Patients and Definitions

In a tertiary hospital, we enrolled 71 consecutive patients with severe unprotected LMCA lesion undergoing emergency procedures following AMI between January 1999 and February 2007. The principal indication was ST-segment elevation AMI (STEAMI) (42 patients, 59%), with primary percutaneous transluminal coronary angioplasty (PTCA) (33 patients) or following failed thrombolysis (6 patients). In 3 patients, STEAMI evolution was >24 h. Of 29 (41%) patients without evidence of ST-elevation on ECG, 20 were in cardiogenic shock. In 9 patients, LMCA was treated for persistent ischemia observed in coronary angiography studies.

We defined AMI as myocardial necrosis marker elevation (CK-MB and troponins) accompanied by electric changes and/or chest pain characteristic of ischemia.[23] Emergency PCI was indicated for AMI with or without hemodynamic instability during the procedure, together with chest pain and persistent dynamic electric changes on ECG, with or without ST-elevation. Severe LMCA lesions were considered to cause signs and symptoms and produced angiographic stenosis >50%. In all patients, LMCA was unprotected and presented no permeable aortocoronary grafts to left anterior descending (LAD) or circumflex (Cx) arteries. We considered distal LMCA lesions bifurcated when they affected the LAD or Cx origins. We defined LMCA occlusion as absence of flow or TIMI flow I in LAD and Cx. We defined cardiogenic shock as systolic blood pressure <90 mm Hg with signs of hypoperfusion or need for vasoactive drugs or intra-aortic balloon counterpulsation (IABC) to maintain blood pressure.

Procedures were considered successful when they resolved angiographic stenosis, with anterograde TIMI III flow without death in the catheterization laboratory.

Events analyzed in the study were any-cause death and repeat revascularization.

Procedure

Initially, we administered 100 IU/kg unfractioned heparin, or 70 IU/kg when associated with glycoprotein (GP) IIb/IIIa inhibitors. Patients receiving conventional stents were administered double antiplatelet therapy for at least 1 month; those receiving drug-eluting stents (DES) had double therapy for at least 1 year. The strategy used in treating bifurcated lesions was left to the discretion of the operator, as was use of predilatation, prophylactic IABC, or intravascular ultrasound.

Drug-eluting stents were first used in our center in March 2003. In the present study we used Cypher (Cordis Corp. Johnson & Johnson), Taxus (Boston Scientific Corporation), and Endeavor (Medtronic) devices. Choice of stent type was at the discretion

of the operator. Clinical follow-up was conducted in all patients through check-ups, reports and telephone calls.

Statistical Analysis

Continuous variables are shown as mean (SD). The Fisher exact test was used to analyze differences in percentages. We constructed univariate logistic regression models to analyze predictors of in-hospital mortality. Multivariate logistic regression analysis of in-hospital mortality included the following variables: occluded LMCA, number of vessels, distal lesion, shock, and incomplete revascularization. We constructed Kaplan-Meier survival curves to determine post-discharge follow-up mortality. Statistical significance was defined as a bilateral value of $P<.05$ or confidence intervals (CI) not including the unit. Calculations were performed using SPSS 13.

RESULTS

Baseline patient characteristics are in Table 1 and angiographic characteristics in Table 2. Lesions affected the bifurcation in 72% of patients; in 30% the RCA was found to be occluded. Procedure characteristics are in Table 3. The most frequently employed technique was provisional stenting (85%). Almost half of the patients received a DES (47%) and in 3 patients implantation was impossible. Forty-seven (66%) patients presented cardiogenic shock. The procedure was successful in 83%.

In-hospital Mortality

Thirty-three (47%) patients died during hospitalization, 11 of these (16%) in the catheterization laboratory. All deaths were cardiac except a hemorrhagic complication in 1 patient with STEAMI. In-hospital mortality was independent of presence or absence of evidence of ST-segment elevation on ECG (48% vs 45%; $P=.92$) and cardiovascular risk factors. Principle predictors of in-hospital mortality are in Table 4. In univariate analysis, increased in-hospital mortality associated with need for IABC and orotracheal intubation, LMCA occlusion, and incomplete revascularization. Multivariate predictors that associated with greater in-hospital mortality were incomplete revascularization and shock.

Mortality and Revascularization in the Long-Term Follow-up

Following discharge, we conducted a median follow-up of 32 (1-88) months in 39 patients.

TABLE 1. **Baseline Characteristics**

Patients	71
Age, mean (SD), y	67 (13)
Men	58 (82)
Tobacco	28 (39)
HBP	34 (48)
DM	33 (47)
Dyslipidemia	24 (34)
LVEF<35%[a]	25 (35)
Prior AMI	16 (23)
Prior stroke	5 (7)
Peripheral artery disease	6 (9)
Previous PCI	6 (9)
Indication	
STEAMI	42 (59)
NSTEAMI	29 (41)

AMI indicates acute myocardial infarction; HBP, high blood pressure; LVEF, left ventricular ejection fraction; NSTEAMI, non-ST elevation acute myocardial infarction; PCI, percutaneous coronary intervention; STEAMI: ST-segment elevation acute myocardial infarction.
[a]LVEF was measured by echocardiography in 51 patients.
Values are expressed as mean (SD) or n (%) of patients.

TABLE 2. **Angiographic Characteristics**

	No. (%)
Location	
Ostial	16 (23)
Medial	4 (6)
Distal	34 (48)
Diffuse	17 (24)
Diseased vessels[a]	
Isolated LMCA	10 (13)
One vessel	14 (18)
Two vessels	23 (32)
Three vessels	24 (34)
Occluded LMCA	10 (14)
Occluded RCA	21 (30)

LMCA indicates left main coronary artery; RCA, right coronary artery.
[a]Diseased vessels independent of coronary artery.

To 47% in-hospital mortality, we added 10.3% any-cause mortality at 1 year of out-of-hospital follow-up, and 28% mortality in the full follow-up (Figure). All deaths were cardiac except 3 (1 stroke, 1 kidney failure, and 1 undetermined death of a patient aged 93 years). Ten (14%) patients required repeat revascularization, 6 of these at the first 6 months. Four of these patients underwent repeat LMCA revascularization (1 patient underwent surgery, the other 3 had PCIs).

Patients With Cardiogenic Shock

Characteristics of patients with shock prior to or during the procedure are in Table 5. Diabetes

TABLE 3. **Characteristics of Procedure**

	No. (%)
DES	33 (47)
Technique	
Provisional	60 (85)
T-stent	3 (4)
Crushing	5 (7)
Without stent	3 (4)
Predilatation	45 (63)
Post-dilatation	25 (35)
Stent diameter	3.5 (0.5)
IVUS	7 (10)
Rotablator	5 (7)
Vessels treated	
LAD	55 (76)
Cx	24 (34)
RCA	14 (20)
Complete revascularization	31 (44)
Success	59 (83)
Shock	47 (66)
Previous	42 (59)
In-procedure	5 (7)
VF	13 (18)
Orotracheal intubation	28 (39)
Pacemakers	10 (14)
IABC	38 (54)

Cx indicates circumflex; DES, drug-eluting stent; IABC, intra-aortic balloon counterpulsation; IVUS, intravascular ultrasound; LAD, left anterior descending; RCA, right coronary artery; VF, ventricular fibrillation.

TABLE 4. **Predictors of Hospital Mortality**

Univariate Analysis	OR (95% CI)	*P*
Provisional stent	0.6 (0.2-1.8)	.4
DES	0.6 (0.2-1.5)	.3
OTI	5.7 (2-16)	<.01
IABC	4.6 (1.6-13)	<.01
Shock	8 (2.4-27)	<.01
Number of vessels	1.6 (1-2.6)	.05
Distal lesion	3.6 (1.2-12)	.03
Occluded RCA	4 (1.5-13)	.01
Incomplete revascularization	6.4 (2.2-18)	<.01
Multivariate analysis		
Shock	5.1 (1.3-20)	.02
Incomplete revascularization	6.3 (1.3-32)	.03

CI indicates confidence interval; DES, drug-eluting stent; IABC, intra-aortic balloon counterpulsation; LMCA, left main coronary artery; OR, odds ratio; OTI, orotracheal intubation; RCA, right coronary artery.

mellitus, number of diseased vessels, and RCA occlusion associated with cardiogenic shock. The percentage of shock was similar in patients with and patients without ST-elevation. In-hospital mortality was greater in patients with shock. Follow-up of patients surviving to discharge revealed no differences in mortality between those with and those without cardiogenic shock (log rank test =0.4).

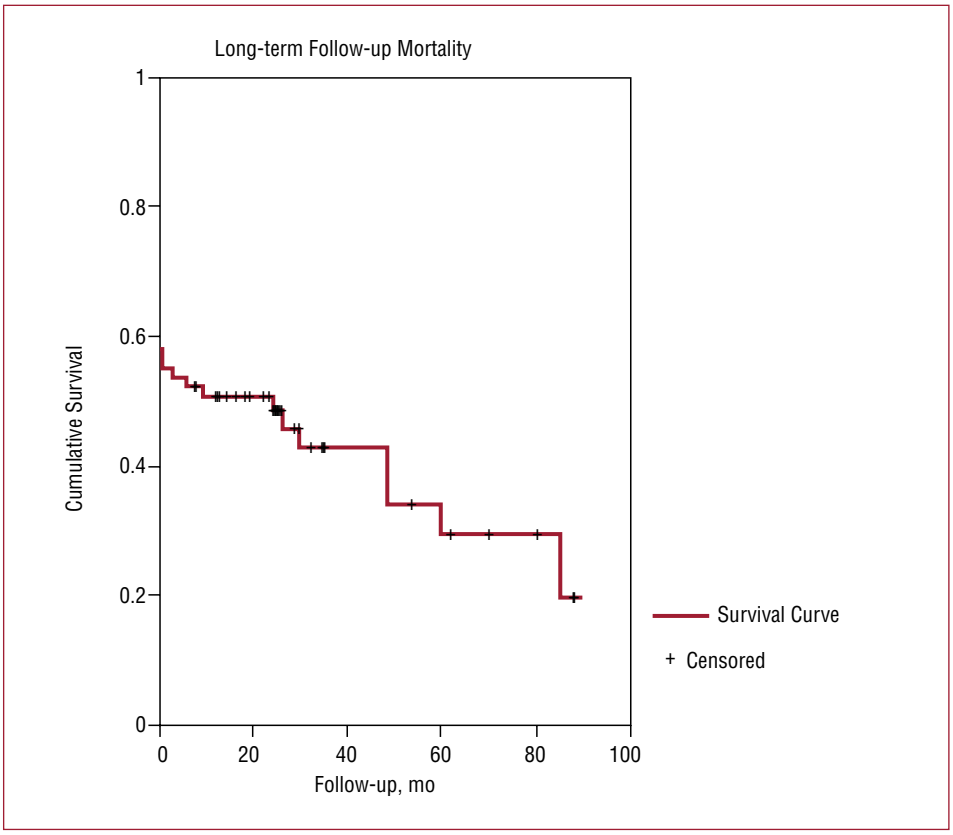

Figure 1. Long-term Kaplan-Meier survival curve

TABLE 5. **Patient Characteristics According to Presence or Absence of Cardiogenic Shock**

	With Shock	Without Shock	*P*
Patients	47 (66)	24 (34)	
Age	67 (12)	68 (16)	.7
Men	38 (81)	20 (83)	.95
Diabetes mellitus	26 (55)	7 (29)	.04
LVEF<35%[a]	20 (59)	5 (21)	.07
LVEF>35%	14 (41)	12 (70)	
Indication			.92
STEAMI	28 (60)	14 (58)	
NSTEAMI	19 (40)	10 (42)	
Angiography			
Number of vessels, mean (SD)	2.1 (1)	1.3 (1)	<.01
Distal lesion	36 (77)	15 (63)	.27
Occluded RCA	18 (38)	3 (13)	.03
Occluded LMCA	9 (20)	1 (4)	.12
In-hospital mortality	29 (62)	4 (17)	<.01

LMCA indicates left main coronary artery; LVEF, left ventricular ejection fraction; NSTEAMI, non ST elevation acute myocardial infarction; RCA, right coronary artery; STEAMI, ST-segment elevation acute myocardial infarction.
[a]LVEF was analyzed in 51 patients.
Values are expressed as mean (SD) or n (%).

DISCUSSION

In this series of patients with AMI and severe unprotected LMCA disease, emergency PCI was a therapeutic option. However, this entails high in-hospital mortality, especially when associated with cardiogenic shock and when complete revascularization is not achieved.

Finding LMCA disease is not infrequent in coronary angiography. It is observed in 5% of patients with stable angina, 7% of patients with AMI, and 3%-5% of coronary angiographies for chest pain or heart failure.[7]

Cardiogenic shock and ST-elevation AMI are urgent conditions requiring immediate treatment.[24] Few previous studies of emergency LMCA surgery exist and these enrolled selected patients. Given that emergency surgery is often unavailable and that these are high-risk patients, percutaneous treatment and mechanical support has been recommended.[9]

However, current data on emergency percutaneous treatment in this situation are scarce. The principle series of LMCA disease treated with angioplasty and coronary stents correspond to stable patients or series of patients, in which urgent procedures represent different, often small, percentages.[9,16,25-28]

In our series, the patients with acute unprotected LMCA disease are at high risk. They present a number of cardiovascular risk factors, prior AMI is frequent, and coronary angiography reveals extensive coronary disease in a high percentage of cases. Cardiogenic shock is the principal complication of emergency percutaneous treatment, which fundamentally distinguishes it from the procedure of choice.[20,26]

In-hospital Mortality

Of 71 patients receiving emergency treatment for LMCA disease, 47% died in hospital, 16% in the catheterization laboratory. Previous studies reported series with similar or greater in-hospital mortality (Marso et al,[11] 70%; Lee et al,[14] 44%) associated with a higher percentage of cardiogenic shock in the population studied. In our series, 66% had cardiogenic shock versus 92% reported by Marso et al.

Two facts not frequently mentioned in the literature are, first, that in-hospital mortality does not differ in patients with and patients without evidence of ST-elevation on ECG and, second, that a substantial number of patients present no evidence of ST-elevation on ECG (41%). This latter percentage is similar to that found in the ULTIMA study (9% with ST-depression; 9%, complete left bundle branch clock; and 12% with no changes on ECG).[11]

In univariate analysis, need for orotracheal intubation and IABC, cardiogenic shock and incomplete revascularization, number of diseased vessels, distal lesion, LMCA occlusion, and RCA occlusion all predicted increased mortality. In multivariate analysis, cardiogenic shock and incomplete revascularization associated with increased mortality. These data reaffirm the indication for complete revascularization in these patients, especially when cardiogenic shock persists.

Previous series describe RCA or left coronary artery occlusion, cardiogenic shock[10,12,19] or need for IABC[13] as predictors of bad prognosis. Other predictors have been absence of collateral circulation in RCA,[12,19] use of inotropics,[16] ST-elevation in aVR and aVL on ECG,[19] and failed procedures.[13]

Distally located lesions affecting the bifurcation also associate with greater mortality.[20] In our series, more than half of the patients presented bifurcated distal lesions which, in univariate analysis, associated with increased in-hospital mortality.

Patients With Cardiogenic Shock

Cardiogenic shock is especially frequent in patients who present diabetes with extensive disease, RCA occlusion or depressed left ventricular ejection fraction. It also occurs in patients with previous conserved ejection fraction. Incidence of cardiogenic shock was similar in patients with

and without ST-elevation. Patients with shock had greater in-hospital mortality (62% vs 17%).

The in-hospital mortality previously described in patients with LMCA disease and cardiogenic shock is high, reaching >80% in several series.[21,22] An earlier registry of 38 patients (73% with shock) found a seven-fold increase in in-hospital mortality in patients with shock.[13]

Mortality and Revascularization During Follow-up

At the first year follow-up, out-of-hospital mortality was 10%; at 32 months follow-up it was 28%. Repeat revascularization was required in 14%, and 6% underwent repeat LMCA revascularization. Previous studies reported incidence of mortality at the first year varied from absence of events in short series to 11% in larger series.[2,12,14-16] In our study, survival curves were similar in patients surviving on admission, independently of the presence or absence of shock during the event, although this analysis may be limited due to the small sample size.

Limitations

When we began our registry, no randomized studies of DES in infarction had been published. Consequently, only 47% of patients received DES. Drug-eluting stents can reduce the restenosis rate during follow-up. We conducted no systematic angiographic follow-up, so the restenosis rate may be an underestimate due to asymptomatic patients. The limited number of participants in our study produces extreme estimates with wide-ranging CIs. Reinfarctions were not analyzed during follow-up after discharge.

CONCLUSIONS

In our series, with a high number of patients with LMCA disease and AMI, percutaneous intervention is a therapeutic option. However, in-hospital mortality continues to be high even in AMI without evidence of ST-segment elevation on ECG, especially if associated with cardiogenic shock and when complete revascularization is not achieved.

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