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Percutaneous Coronary Intervention of Unprotected Left Main Coronary Artery Disease as Culprit Lesion in Patients With Acute Myocardial Infarction

Alessandro Pappalardo, MD,* Mamas A. Mamas, MD,‡ Fabrizio Imola, MD,* Vito Ramazzotti, MD,* Alessandro Manzoli, MD,* Francesco Prati, MD,*† Magdi El-Omar, MD‡

Rome, Italy; and Manchester, United Kingdom

Objectives This study sought to evaluate short- and long-term outcomes of patients undergoing emergency percutaneous coronary intervention (PCI) for acute myocardial infarction due to a culprit lesion in an unprotected left main coronary artery.

Methods In this retrospective, 2-center, international observational study, 5,261 patients were admitted between February 2005 and December 2008 with acute myocardial infarction and treated with PCI; of these, 1,277 were ST-segment elevation myocardial infarction and 3,984 non–ST-segment elevation myocardial infarction. We identified 48 patients among this cohort who underwent emergency PCI to an unprotected left main coronary artery culprit lesion.

Results Mean age was 70 ± 12.5 years, and 45% of the patients presented with ST-segment elevation myocardial infarction or new left bundle branch block. Cardiogenic shock was present in 45%, and distal left main coronary artery disease was present in 71% of patients. Angiographic procedural success was achieved in 92% of patients. Overall in-hospital mortality was 21%, due in all cases to refractory, multiorgan failure. Twenty-five percent experienced major adverse cardiac events, defined as death, myocardial infarction, stent thrombosis, and target vessel revascularization. In patients presenting in cardiogenic shock, in-hospital mortality was 32%. At 1-year follow-up, in-hospital survivors had a mortality rate of 10.5%, whereas 18.4% experienced subsequent major adverse cardiac events. Long-term prognosis was excellent in hospital survivors with a 1-year survival rate of 89.5%.

Conclusions Patients with acute myocardial infarction and thrombosis of the unprotected left main coronary artery are a high-risk subgroup with a substantial mortality, particularly if they present in cardiogenic shock. We demonstrate that in these patients, PCI is a feasible treatment option associated with reasonably good outcomes. Long-term prognosis is excellent in hospital survivors with an 89.5% survival rate at 1 year. (J Am Coll Cardiol Intv 2011;4:618–26) © 2011 by the American College of Cardiology Foundation

From the *Department of Interventional Cardiology, San Giovanni-Addolorata Hospital, Rome, Italy; †CLI Foundation, Rome, Italy; and the ‡Department of Cardiology, Manchester Royal Infirmary, Manchester, United Kingdom. The authors have reported that they have no relationships to disclose.

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Between 4% and 7% of patients with acute myocardial infarction (AMI) have significant involvement of the left main coronary artery (LMCA) (1,2). Patients with AMI due to thrombosis within an unprotected left main coronary artery (ULMCA) are a small but critically ill subgroup, characterized by frequent presentation with cardiogenic shock and high in-hospital major adverse cardiac event (MACE) rates (3,4). The standard revascularization strategy for patients with significant disease in a ULMCA is coronary artery bypass graft (CABG) surgery (5). Such a strategy, however, carries very high mortality and morbidity in patients presenting with AMI and ULMCA thrombosis (6). Traditionally, significant disease of a ULMCA has been considered a relative or absolute contraindication to percutaneous transluminal coronary angioplasty, with or without bare-metal stenting, because of high rates of abrupt vessel closure, restenosis, and target vessel revascularization (7–11). Improved results have been reported with drug-eluting stents (DES), with a 1-year mortality rate between 0% and 4% (12–18). However, the available data on the short- and long-term outcomes of percutaneous coronary intervention (PCI) on LMCA lesions in the setting of AMI is very limited and mainly derived from small registry studies, often from single centers, consisting of between 12 and 40 patients (19–25). Indeed, even in the most recent data from GRACE (Global Registry of Acute Coronary Events), only 41 of 514 patients with ULMCA who underwent PCI in the setting of an acute coronary syndrome (ACS) had LMCA disease alone as a culprit lesion (26), and less than one-half of the patients treated with a PCI strategy underwent revascularization on the day of admission. Thus, outcomes associated with urgent revascularization in the emergency setting remain largely undefined.

The aim of the present retrospective analysis is to evaluate the short- and long-term outcomes associated with PCI to culprit ULMCA lesions in patients with AMI.

Methods

Patient population. We retrospectively analyzed 48 consecutive patients presenting with AMI to San Giovanni Hospital, Rome, Italy, and Manchester Royal Infirmary, Manchester, United Kingdom, from February 2005 to December 2008, who were treated with emergency PCI to a culprit ULMCA lesion. The decision to proceed to emergency cardiac catheterization was based on the presence of prolonged (>30 min)/ongoing chest pain, coupled with electrocardiogram changes of acute ST-segment elevation myocardial infarction (STEMI), new/presumed new left bundle branch block, or persistent, widespread ST-segment depression refractory to medical therapy (non–ST-segment elevation myocardial infarction [NSTEMI]), with or without cardiogenic shock. Over the same period, 5,261 patients were treated at the 2 centers with PCI for ACS, 1,277 with STEMI and 3,984 with NSTEMI. All patients at San Giovanni Hospital (n = 36) underwent PCI due to the absence of cardiac surgical support at that hospital, whereas those at the Manchester Royal Infirmary (n = 12) were initially discussed with the cardiothoracic surgeons but were turned down due to a perceived high surgical risk.

Percutaneous coronary intervention. Aspirin was administered as a 250-mg intravenous bolus to all patients presenting to San Giovanni Hospital, at the referring center, in the ambulance, or upon arrival at the hospital. In contrast, aspirin was administered as a 300-mg oral dose at the point of first medical contact in all patients presenting to the Manchester Royal Infirmary. Clopidogrel was administered as a 600-mg oral loading dose at the first point of medical contact before the procedure. Glycoprotein IIb/IIIa inhibitors were administered in all patients presenting with STEMI and in 3 patients presenting with NSTEMI. Unfractionated heparin was administered as a weight-adjusted intravenous or intra-arterial bolus given at the time of PCI. An intravenous infusion of heparin was also given to patients requiring an intra-aortic balloon pump (IABP).

Demographics and follow-up. Demographic, procedural, and outcome data were obtained from review of the catheterization laboratory database as well as the case notes at the 2 centers. All angiograms were reviewed by each set of authors at each respective center to confirm angiographic findings and outcomes. Clinical follow-up was obtained in all patients through outpatient clinic visits and/or telephone interviews. Routine follow-up angiography was performed in 44% of patients.

Endpoints and study definitions. MACE was assessed during hospitalization and at follow-up and was defined as death, recurrent myocardial infarction (re-AMI), stent thrombosis (ST), and target vessel revascularization during hospitalization and at 1-year follow-up. Myocardial infarction was defined as cardiac sounding chest pain associated with a rise in serum troponin (T or I) level exceeding the 99th percentile

Abbreviations and Acronyms

ACS = acute coronary syndrome(s)
AMI = acute myocardial infarction
CABG = coronary artery bypass graft
DES = drug-eluting stent(s)
IABP = intra-aortic balloon pump(s)
LAD = left anterior descending artery
LCX = left circumflex artery
LMCA = left main coronary artery
MACE = major adverse cardiac event(s)
NSTEMI = non–ST-segment elevation myocardial infarction
PCI = percutaneous coronary intervention
RCA = right coronary artery
ST = stent thrombosis
STEMI = ST-segment elevation myocardial infarction
TIMI = Thrombolysis In Myocardial Infarction
ULMCA = unprotected left main coronary artery

of a normal reference population ± new electrocardiogram changes (ST-segment elevation or depression >1 mm, T-wave changes, or left bundle branch block) in 2 or more contiguous leads (27). Cardiogenic shock was defined as sustained hypotension (systolic blood pressure <90 mm Hg) with signs of tissue hypoperfusion including cool extremities, oliguria (<30 ml/h), and altered level of consciousness. The LMCA was considered "unprotected" if there was no previous history of CABG, or if CABG had been performed, but no patent grafts were demonstrated on angiography. PCI was defined as angiographically successful when the residual diameter stenosis was <20% and TIMI (Thrombolysis In Myocardial Infarction) flow grade 3 was achieved in the main vessel and its major branches. Binary restenosis was considered present when a stenosis >50% at the segment site (intrastent and 5 mm proximal and distal to the stent) was observed at follow-up coronary angiography regardless of the clinical symptomatology of the patient. Stent thrombosis was classified according to the Academic Research Consortium definition as definite, probable, or possible; and as early (0 to 30 days), late (31 to 360 days), and very late (>360 days) (28). Briefly, definite ST requires the presence of an acute coronary syndrome with angiographic or autopsy evidence of thrombus or occlusion. In contrast, probable ST is defined as any unexplained cardiac death within 30 days after the index procedure or AMI involving the target vessel territory without angiographic confirmation, whereas possible ST is defined as unexplained cardiac death occurring at least 30 days after the index procedure.

Target lesion revascularization was defined as any revascularization performed on the treated segment, whereas target vessel revascularization was defined as any reintervention performed on any segment of the treated vessel. Target lesion revascularization of the distal LMCA was defined as revascularization to treat a stenosis >50% within 5 mm distal to the left main bifurcation including the ostium of the left anterior descending artery and/or left circumflex artery. Deaths were classified as either cardiac or noncardiac. Sudden death or deaths of unknown cause were considered cardiac.

Statistical analysis. All data are presented as mean ± SD. Categorical variables were compared using Fisher exact test. Univariate logistic regression analysis was performed with death as the dependent variable. Independent variables studied included: age >60 years, presentation with cardiogenic shock, DES use, diabetes, glycoprotein IIb/IIIa inhibitor use, left main stem ostial lesion, left main stem distal lesion, significant right coronary artery (RCA) involvement, multivessel stenting, presence of collaterals, IABP use, and clinical presentation with STEMI. Multivariate stepwise logistic regression analysis was performed in which independent variables were removed from the model if $p > 0.1$.

Results

Baseline clinical data. Demographic and clinical characteristics of 48 consecutive patients undergoing PCI to a ULMCA at the 2 centers following presentation with STEMI/NSTEMI are presented in Table 1. The mean age of the cohort treated was 70 ± 12.5 years. Of these, 12 patients (25%) had a prior history of diabetes mellitus, 22 patients (45%) presented with STEMI, whereas the remaining 26 patients (55%) presented with NSTEMI. A total of 22 patients (45%) were in cardiogenic shock upon arrival in the catheterization laboratory, and of these, 13 (59.1%) presented with NSTEMI, and 9 (40.9%) presented with STEMI.

A significant proportion of patients required circulatory and/or ventilatory support as evidenced by use of IABP in 54% of cases, orotracheal intubation with assisted ventilation in 20% of cases, and pharmacological inotropic support in 37% of cases. The latter 2 were only used in cardiogenic shock cases, whereas IABP was used in all cardiogenic shock cases in addition to 4 cases without cardiogenic shock, either prophylactically or because of hemodynamic instability that developed during the procedure.

Angiographic and procedural characteristics. The angiographic and procedural characteristics are presented in Tables 2 and 3. The LMCA was judged the culprit vessel in all patients, and distal involvement was the most common finding (71%) (Table 2). Significant coexistent disease of the RCA was documented in 26 patients (54%). Of the 12 patients in whom the RCA was completely occluded, 7 were in cardiogenic shock. Significant left anterior descending (LAD) and left circumflex (LCX) artery disease was present in 32 (66.6%) and 21 (43.7%) patients, respectively.

Multivessel PCI was performed in 23 (48%) patients, as summarized in Table 3. Briefly, 20 patients had PCI to

Table 1. Baseline Demographic and Clinical Characteristics of Study Patients

Age, yrs	70±12.5
Male/female	36/12 (75%)
Hypertension >140/90 mm Hg	33 (69%)
Hypercholesterolemia, LDL >130 mg/dl	19 (39%)
Diabetes mellitus, pre-existing	12 (25%)
Chronic renal failure, creatinine >1.5 mg/dl	8 (16%)
Smoking	25 (52%)
STEMI or new LBBB	22 (45%)
NSTEMI	26 (55%)
Cardiogenic shock/Killip class IV	22 (45%)
Logistic EuroSCORE	37.89±21.80
GRACE score	210±42.84

Values are mean ± SD or n (%).

EuroSCORE = European System for Cardiac Operative Risk Evaluation; GRACE = Global Registry of Acute Coronary Events; LBBB = left bundle branch block; LDL = low-density lipoprotein; NSTEMI = non–ST-segment elevation myocardial infarction; STEMI = ST-segment elevation myocardial infarction.

Table 2. Angiographic Data

Ostial and/or body LMCA disease	14 (29%)	
Distal LMCA disease	34 (71%)	
LMCA disease only	4 (8%)	
LMCA + 1-vessel disease	11 (23%)	
LMCA + 2-vessel disease	17 (35%)	
LMCA + 3-vessel disease	16 (34%)	
LAD stenosis	32 (66.6%)	
LCX stenosis	21 (43.7%)	
RCA stenosis (total)	26 (54%)	
RCA occlusion	12 (25%)	
Collateral circulation, Rentrop class		
0–1	25 (52%)	
2–3	23 (48%)	
Stenosis severity	Pre-PCI	Post-PCI
100%	22 (46%)	0
75%–99%	21 (44%)	2 (4%)
50%–74%	5 (10%)	1 (2%)
20%–49%	0 (0%)	1 (2%)
<20%	0 (0%)	44 (92%)
LMCA TIMI flow grade	Pre-PCI	Post-PCI
0	7 (14.5%)	0
1	7 (14.5%)	1 (2%)
2 or 3	34 (71%)	46 (96%)
No reflow	0 (0%)	1 (2%)
Angiographic success		44 (92%)

LAD = left anterior descending artery; LCX = left circumflex artery; LMCA = left main coronary artery; PCI = percutaneous coronary intervention; RCA = right coronary artery; TIMI = Thrombolysis In Myocardial Infarction.

LMCA and 1 other coronary artery (RCA: 4 [8%], LAD: 13 [27%], and LCX: 3 [6%]). Three patients had PCI to LMCA and 2 other coronary arteries (LAD and LCX: 1 patient [2%], RCA and LAD: 1 patient [2%], and RCA and LCX: 1 patient [2%]). Of 34 (71%) patients with distal LMCA disease, 30 (88%) were treated with a provisional stenting technique, whereas in the remaining 4 patients (12%), a "V" stenting, simultaneous kissing stenting, or modified T stenting technique was used. The remaining 14 patients, who had ostial and/or mid-shaft LMCA disease, were treated with a simple stenting technique with or without prior balloon pre-dilation. Coronary stents were used in 44 patients (92%): 29 patients (61%) received DES, and 15 patients (31%) received bare-metal stents. In 4 patients (8%), stent deployment was not possible. In 1 case, the LMCA was severely calcified, and despite rotablation and removal of a significant amount of plaque, it proved impossible to deliver a stent, with a suboptimal final angiographic result (stenosis <50%). In the remaining 3 patients, it was not possible to intervene on the LMCA due to the inability to pass a guidewire and/or an angioplasty balloon into the LAD or LCX because of heavy calcification and/or an acute takeoff angle of the LMCA. Of these 3 remaining patients, 1 underwent CABG during hospitalization, and the other 2 died.

Angiographic success (stenosis <20% in the ULMCA and ostia of the main branches) was achieved in 44 (92%) of the 48 patients, with partial success achieved in 1 case (stenosis <50%) and procedural failure in 3 cases because of technical difficulties outlined herein.

In-hospital outcomes. In hospital and long-term clinical outcomes are illustrated in Table 4. In patients who presented in cardiogenic shock, in-hospital mortality was 32%, whereas in patients who were hemodynamically stable at presentation, in-hospital mortality was 11.5% ($p = 0.08$). Ten patients (20.8%) died in hospital, all secondary to refractory cardiogenic shock and multiorgan failure. Univariate logistic regression analysis was performed in which the effects of variables, including age >60 years, presentation with cardiogenic shock, DES use, diabetes mellitus, glycoprotein IIb/IIIa inhibitor use, LMCA ostial lesion, LMCA distal lesion, significant RCA involvement, multivessel stenting, presence of collaterals, IABP use, clinical presentation with STEMI, and angiographic success on in-hospital mortality outcomes were studied. A summary of the data is presented in Table 5. Multivariate stepwise

Table 3. Procedural Data

Total number of LMCA stents, n	51
BMS	20 (39%)
DES	31 (61%)
Mean number of LMCA stents per patient	1.06 ± 0.48
Bifurcation stenting technique	
Provisional stenting	27 (56%)
T-stenting	1 (2%)
Simultaneous kissing stenting	1 (2%)
V-stenting	2 (4%)
Rotablator without stenting	1 (2%)
Cutting balloon + stent	1 (2%)
Distal LMCA procedural failure	2 (4%)
Ostial LMCA procedural failure	1 (2%)
Optical coherence tomography use	1 (2%)
Intravascular ultrasound use	1 (2%)
Glycoprotein IIb/IIIa antagonists	25 (52%)
Aspirin	48 (100%)
Clopidogrel	36 (75%)
IABP	26 (54%)
Inotropic support	18 (37%)
Thrombectomy catheter	3 (6%)
PCI to LMCA only	25 (52%)
PCI to LMCA + LAD	13 (27%)
PCI to LMCA + LAD + LCX	1 (2%)
PCI to LMCA + LCX	3 (6%)
PCI to LMCA + RCA	4 (8.3%)
PCI to LMCA + RCA + LAD	1 (2%)
PCI to LMCA + RCA + LCX	1 (2%)

Values are mean ± SD or n (%).

BMS = bare-metal stent(s); DES = drug-eluting stent(s); IABP = intra-aortic balloon pump(s); other abbreviations as in Table 2.

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Table 4. In-Hospital and 1-Year Clinical Outcomes

In-hospital outcomes	
Angiographic success	44 (92%)
Death, total	10 (21%)
Reinfarction, total	2 (4%)
Stent thrombosis, definite	1 (2%)
MACE, total	12 (25%)
Repeat percutaneous target lesion revascularization	1 (2%)
Bypass graft surgery	1 (2%)
Death in patients with shock/Killip class IV	7 (32%)
Death in hemodynamically stable patients	3 (11.5%)
Stroke	0 (0%)
Out-of-hospital long-term outcomes	
Mean follow-up duration	365 ± 17.58
Death, total	4 (10.5%)
Reinfarction	4 (10.5%)
Stent thrombosis, possible	4 (10.5%)
MACE at 1 yr, total	7 (18.4%)
Repeat percutaneous target lesion revascularization	0 (0%)
Bypass graft surgery	3 (7.9%)
Death in patients with shock/Killip class IV	1 (2.6%)
Death in hemodynamically stable patients	3 (7.9%)

Values are n (%) or mean ± SD.
MACE = major adverse cardiac event(s).

logistic regression analysis was performed in which variables included in the univariate analysis with a $p > 0.1$ were removed from the model. No variables were identified that were independently predictive of in-hospital mortality.

In addition to the in-hospital deaths described herein, there were 2 in-hospital MACE events due to a new NSTEMI. In the first of these, there was definite ST in the LMCA (nonocclusive) and LCX (occlusive) in a patient who had undergone PCI to the LMCA with a T-stenting technique. Percutaneous transluminal coronary angioplasty was successfully used to treat the LMCA, but attempts at recanalization of the LCX failed. Six months later, the patient underwent elective CABG due to significant in-stent restenosis within the LMCA. The second patient, in whom the original attempt at PCI to LMCA ostium was unsuccessful, developed chest pain with dynamic electrocardiogram changes and a raised troponin level 5 days following admission and subsequently underwent successful CABG.

One-year outcomes. The overall mortality rate from the index presentation up to 1-year following discharge was 29% (14 of 48 patients). From hospital discharge to 1-year follow-up, an additional 4 patients died due to possible ST: 3 had PCI to the distal LMCA, and 1 had PCI to the LMCA ostium and mid-LAD. Thus, the 1-year survival rate of in-hospital survivors was excellent at 89.5%. Univariate logistic regression analysis was performed in which the effects of variables, including age >60 years, presentation with cardiogenic shock, DES use, diabetes mellitus, glycoprotein IIb/IIIa inhibitor use, LMCA ostial lesion, LMCA distal lesion, significant RCA involvement, IABP use, clinical presentation with STEMI, and angiographic success were studied on 1-year mortality outcomes. A summary of the data is presented in Table 6. Multivariate analysis did not identify any variables that were independently predictive of 1-year mortality.

The overall MACE rate from the index presentation up to 1 year following discharge was 39.6% (19 of 48 patients). The 1-year MACE rate for in-hospital survivors was 18.4% and comprised events in 7 patients: 4 were deaths as outlined herein, and the remaining 3 patients underwent CABG following demonstration of significant in-stent restenosis on routine coronary angiography at 6 months after the index event.

Table 5. Univariate Predictors of In-Hospital Mortality

Variable	Odds Ratio (95% CI)	p Value
Age >60 yrs	1.38 (0.29–6.44)	0.68
Cardiogenic shock	3.58 (0.80–16.05)	0.08
DES	0.68 (0.15–2.97)	0.61
Diabetes	0.36 (0.04–3.22)	0.36
GP IIb/IIIa inhibitor use	0.25 (0.05–1.33)	0.08
IABP	0.31 (0.07–1.40)	0.11
LMS distal	4.68 (0.53–41.07)	0.11
LMS ostial	0.31 (0.03–2.77)	0.24
Significant RCA disease	1.35 (0.33–5.57)	0.68
Presentation with STEMI	0.23 (0.04–1.20)	0.06
Angiographic success	0.22 (0.03–1.83)	0.16
Collateral circulation presence	0.48 (0.27–1.48)	0.07
Multivessel stenting	1.92 (0.47–7.87)	0.36

CI = confidence interval; GP = glycoprotein; LMS = left main stem coronary artery; other abbreviations as in Tables 1 and 3.

Table 6. Univariate Predictors of 1-Year Mortality

Variable	Odds Ratio (95% CI)	p Value
Age >60 yrs	1.32 (0.30–5.84)	0.71
Cardiogenic shock	1.90 (0.54–6.71)	0.32
DES	0.58 (0.16–2.16)	0.42
Diabetes	0.54 (0.10–2.95)	0.48
GP IIb/IIIa inhibitor use	0.24 (0.05–1.03)	0.06
IABP	0.25 (0.06–0.95)	0.04
LMS distal	1.75 (0.41–7.59)	0.45
LMS ostial	0.46 (0.08–2.48)	0.37
Significant RCA disease	1.80 (0.50–6.50)	0.37
Presentation with STEMI	0.21 (0.05–0.91)	0.04
Angiographic success	0.38 (0.05–2.97)	0.35

Abbreviations as in Tables 1, 3, and 5.

Discussion

In one of the largest series to date describing the results of urgent PCI to ULMCA, we report herein that emergency PCI to a ULMCA culprit lesion in patients with ACS is a feasible therapeutic option with acceptable MACE rates and should be considered in patients presenting with AMI in the acute setting. Primary PCI of the ULMCA is technically feasible in most patients and has the advantage of providing more rapid reperfusion compared with CABG, with acceptable short- and long-term outcomes.

Our observed result of a 21% in-hospital mortality rate compares favorably with those published previously for similar patient cohorts, which varied between 33% and 58% (19–24), despite the fact that 45% of our patients presented in cardiogenic shock. We also demonstrate that patients who present in cardiogenic shock have a trend toward a higher in-hospital mortality rate than do those who are hemodynamically stable (odds ratio: 3.58, 95% confidence interval: 0.80 to 16.05; $p = 0.08$). Other studies such as those of De Luca et al. (19), Prasad et al. (22), Hurtado et al. (23), and Jensen et al. (24) have demonstrated that presentation with cardiogenic shock is independently associated with mortality. Possible explanations for the lower mortality rates observed in the current series compared with those reported previously (19–22) include the lower proportion of patients with cardiogenic shock at presentation in the current study (45%) compared with the other studies (63% to 92%). Indeed, in Lee et al. (29), the 1 study in which a lower in-hospital mortality rate (8%) was reported, the proportion of patients with cardiogenic shock at presentation was only 24%. Another potential explanation relates to the proportion of patients with STEMI because Jensen et al. (24) demonstrated worse outcomes associated with STEMI presentation compared with those with NSTEMI, although other investigators have shown no differences (29). In the current series, only 45% of patients presented with STEMI, whereas in other reports, the proportion was considerably higher. Recently, data from the GRACE registry has been published on ULMCA revascularization in patients presenting with ACS (26). In this cohort, 514 patients underwent PCI and 612 underwent CABG, with an overall in-hospital mortality rate of 11%. Patients presenting with cardiogenic shock had a mortality rate of 40%. Although the GRACE registry data on ULMCA revascularization are far larger than ours (514 vs. 48 patients, respectively), the 2 cohorts are very different. Our series presents data on patients undergoing emergency ULMCA revascularization within a few hours of arrival at the interventional center. By contrast, less than one-half of patients treated with a PCI strategy in the GRACE registry underwent revascularization on the day of admission and only 69% within 48 h. Furthermore, only a minority of patients included in the GRACE registry presented with cardiogenic shock (5.1%) compared with 45% of patients in the current study.

There is only limited data on emergency CABG in patients with AMI due to significant ULMCA disease (30,31). One study reported a 19% in-hospital mortality rate in patients with ACS and significant LMCA disease who underwent CABG (30). For the subgroup of patients presenting with cardiogenic shock pre-operatively and developing a low cardiac output state and multiorgan failure post-operatively, the in-hospital mortality rate was much higher at 75% (30). Another study reported on 13 patients with an AMI and significant LMCA stenosis who underwent emergency CABG (6). In that study, the perioperative mortality for the group as a whole was 46%, whereas for the cardiogenic shock subgroup, it was higher at 53%. The reported overall in-hospital mortality rate in the GRACE registry for patients who underwent CABG for LMCA disease was quite low at 5.4%. The corresponding mortality rate for the subgroup of patients with cardiogenic shock was also relatively low at 30%. It must, however, be emphasized that only 5.1% of patients had CABG on the same day of admission and 25% had CABG within 48 h. The median delay from the time of admission to CABG revascularization was 4.5 days. Furthermore, only 1.7% of these patients were in cardiogenic shock at presentation. It is therefore most likely that the surgically revascularized patients in the GRACE registry represented a more stable cohort of patients compared with patients in the current study. Indeed, even within the GRACE registry, patients who underwent CABG had significantly lower GRACE risk scores than did those who underwent PCI and, therefore, represented a more stable cohort of patients. When comparing PCI with CABG in the acute setting of AMI, it must be remembered that clinical outcome is improved with any revascularization versus medical therapy alone. Furthermore, among revascularization patients, a treatment bias favoring performance of PCI rather than CABG in higher clinical-risk patients prohibits direct comparison between the 2 revascularization modalities and despite differences in patient groups and decisions for treatment, ULMCA PCI in STEMI is associated with similar survival rates compared with CABG (25).

AMI due to ULMCA disease is often complicated by hemodynamic instability, frank cardiogenic shock, or resuscitated cardiac arrest. In such critically ill patients, prompt and complete reperfusion of the occluded vessel is essential to improve prognosis. Because cardiothoracic surgeons are generally reluctant to undertake emergency CABG on hemodynamically unstable patients, particularly in the context of an AMI, PCI has become the preferred mode of revascularization in patients with ACS due to ULMCA disease. This has recently been illustrated in the GRACE registry, where over its 8-year period (2000 to 2007), and

despite relatively constant GRACE risk scores, the rate of CABG had fallen from 45% to 25%, with a corresponding rise in the rate of PCI from 18% to 40% (26).

PCI to ULMCA is often a complex procedure, requiring a combination of skill and speed, particularly in the acute setting when patients are often hemodynamically unstable. In such cases, every attempt should be made to keep the procedure as simple as possible. Consequently, in this study, most bifurcation lesions were treated with a provisional side branch stenting technique, with only 4 cases (8%) requiring an alternative technique, such as V-stenting, simultaneous kissing stenting, or modified T-stenting. The provisional side branch stenting technique is the simplest PCI strategy for LMCA bifurcation lesions. Other studies of patients with STEMI undergoing emergent PCI to a culprit LMCA lesion have also reported the preferential use of a single stent strategy, reserving more complex strategies, such as V-stenting and T-stenting, for a minority of cases (24). In addition to simplicity, a provisional side branch stenting strategy, compared with a double-vessel stenting strategy, has been shown to be associated with lower restenosis rates (32–34).

The use of aspiration/thrombectomy catheters is commonplace in primary PCI (35) and TAPAS (Thrombus Aspiration During Percutaneous Coronary Intervention in Acute Myocardial Infarction Study) has shown that the use of thrombectomy during primary PCI is associated with a decrease in cardiac death or reinfarction at 1 year (36). In our registry, the use of thrombectomy devices was limited to 3 of 22 patients (13.6%) undergoing primary PCI for STEMI; in the remaining primary PCI cases, thrombus was managed pharmacologically or mechanically using angioplasty balloons. Many of the patients included in this series were hemodynamically unstable; therefore, the main objective in these cases was the rapid establishment of antegrade coronary flow, avoiding any steps, including the routine use of thrombectomy devices, that may prolong the procedure, with potentially an unfavorable influence on patient outcome. Other recent studies have similarly reported low rates of thrombectomy device use in STEMI patients undergoing PCI to LMCA (24), presumably for similar reasons.

The anatomic pattern of restenosis after distal LMCA stenting is mostly focal and often involves the left circumflex ostium (37), where an acute angle of takeoff may predispose to malapposition of stent struts. Consequently, we would recommend that single-stent strategies be used for distal LMCA lesions where possible, to minimize the risks of ST and restenosis.

We recorded 1 case of definite in-hospital ST and 4 cases of possible late ST, with a combined 1-year rate of 10%. This relatively high rate of ST may be due in part to the high-risk profile of the patient cohort studied, and in part to the lack of systematic optimization of the final stent result with intravascular ultrasound/optical coherence tomography. The latter, however, is often precluded by the patient's hemodynamic instability. It remains possible that had more powerful antiplatelet agents been used in this cohort, the observed rates of ST would have been lower (38).

According to the 2009 American College of Cardiology/American Heart Association STEMI treatment guidelines for PCI (39), stenting can be considered in patients with anatomic and clinical conditions that predict an increased risk of adverse surgical outcomes (Class IIb). However, randomized trials have been and/or would be too complex to set up in view of the instability of these patients as well as the logistic complexities and treatment biases that favor one therapy over the other. However, fundamental issues specific to PCI in the treatment of UMLCA in the acute setting that should be considered include: 1) possible advantages of PCI with respect to more rapid reperfusion compared with CABG; 2) efficacy of DES; 3) technical considerations regarding the treatment of the distal ULMCA; 4) duration of dual antiplatelet therapy; 5) role of IABP for hemodynamic support; and 6) possible advantages of PCI with respect to lower risk of stroke compared with CABG (25).

Study limitations. This report retains all the well-recognized limitations of a retrospective, nonrandomized study. PCI was not performed according to standardized protocols, and the interventional strategy was chosen according to operator preference. Nonetheless, the study represents a "real-world" cohort of patients undergoing real-world interventional treatment, and, therefore, reflects current practice more reliably than that in the pivotal, published clinical trials. The number of patients in this series is small, although this reflects the relative rarity of ULMCA-related infarcts. Furthermore, such small cohorts with a small number of endpoints limit the strength of multivariate analyses that should be viewed as hypothesis-generating in the current context. Finally, routine follow-up angiography was performed in nearly one-half the patients, and this may have artificially raised the number of repeat interventions.

Conclusions

ULMCA culprit disease in patients presenting with ACS is rare but is associated with high in-hospital mortality, especially in those presenting with cardiogenic shock. We demonstrate in this study that PCI is a feasible treatment option in these patients and is a reasonable alternative to surgical revascularization. Despite the extensive use of hemodynamic support, a 21% in-hospital mortality rate was observed in this study, although for those who survive to hospital discharge, a much better prognosis is recorded, with an 10.5% mortality rate at 1 year. Without randomized trial data, the decision to perform CABG or PCI in AMI patients with ULMCA disease is difficult, and the decision needs to be individualized, taking into consideration potential risks involved for each treatment strategy. Ultimately,

randomized, controlled trials will be needed to further elucidate the optimal treatment strategy, although PCI is both feasible and associated with acceptable outcomes as demonstrated in this study.

Reprint requests and correspondence: Dr. Alessandro Pappalardo, San Giovanni Hospital, Via Amba Aradam 9, Rome 00184, Italy. E-mail: pplsn58m09h501h@libero.it. OR Dr. Magdi El-Omar, Manchester Heart Centre, Manchester Royal Infirmary, Oxford Road, Manchester M13 9WL, United Kingdom. E-mail: magdi.el-omar@cmft.nhs.uk.

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