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ORIGINAL ARTICLE

CLINICAL RESULTS OF PERCUTANEOUS TREATMENT IN ACUTE MYOCARDIAL INFARCTION DUE TO LEFT MAIN CORONARY ARTERY STENOSIS

KLINIČKI REZULTATI PERKUTANOG LEČENJA STENOZE NA GLAVNOM STABLU LEVE KORONARNE ARTERIJE U AKUTNOM INFARKTU MIOKARDA

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Abstract

Introduction: Acute myocardial infarction due to left main coronary artery stenosis is a rare, but life-threatening event often accompanied by sudden cardiac death and/or cardiogenic shock. The optimal revascularization strategy for unprotected left main coronary artery disease is the subject of ongoing debate, especially in urgent settings, where immediate optimal acute angiographic result is required to ensure patient survival and improve prognosis.
Aim: This study aims to investigate patient characteristics and procedural and clinical variables associated with favorable outcomes of percutaneous treatment.
Material and methods: A number of 40 patients undergoing PCI with acute myocardial infarction due to left main coronary artery stenosis were reviewed retrospectively from 1st January 2019 to 21st December 2022.
Results: There was a total of 40 patients with a mean age of 70.83 ± 11.415. Cardiogenic shock occurred in 20 (50%) patients. Two patients (5%) died in the catheterization laboratory and 16 (40%) died during hospitalization. Twenty-two patients survived to be discharged; five patients died during the follow-up period. The overall mortality rate was 23 (57.5%). Factors associated with increased mortality included female gender (p = 0.008), cardiogenic shock (p = 0.025) and inotropes (p = 0.000).
Conclusion: Acute myocardial infarction caused by left main coronary artery stenosis is complicated by high incidence of cardiogenic shock and mortality. In univariate analysis, cardiogenic shock, female gender and usage of inotropes correlated with death. Emergency PCI provides an important treatment option in these high-risk patients, but mortality remains high.

Keywords:
acute myocardial infarction,
percutaneous coronary intervention,
left main coronary artery

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Sažetak

Uvod: Akutni infarkt miokarda izazvan lezijom na glavnom stablu leve koronarne arterije redak je, ali životno ugrožavajući događaj, često povezan sa iznenadnim smrtnim ishodom i/ili kardiogenim šokom. Optimalna strategija za revaskularizaciju ovih pacijenata je i dalje predmet debate, pogotovo u urgentnim situacijama gde je neophodno brzo osigurati optimalni angiografski rezultat kako bismo poboljšali prognozu bolesnika.
Cilj: Cilj ovog rada je da istraži karakteristike pacijenata, proceduralne i kliničke varijable kao prediktore ishoda nakon perkutane koronarne intervencije kod bolesnika sa akutnom lezijom na glavnom stablu leve koronarne arterije.
Materijal i metode: Retrospektivno je analizirano 40 pacijenata sa akutnim infarktom miokarda usled lezije na glavnom stablu, kojima je rađena perkutana koronarna intervencija u periodu od 01.01.2019. do 21.12.2022. godine.
Rezultati: Prosek godina ispitivane populacije, koju je činilo 40 pacijenata, bio je 70,83 ± 11,415. Kardiogeni šok je bio prisutan kod njih 20 (50%). Tokom procedure su preminula 2 pacijenta (5%), a tokom hospitalizacije 16 (40%). Od 22 pacijenta koji su uspešno otpušteni sa bolničkog lečenja, pet pacijenata je preminulo tokom perioda praćenja. Ukupni mortalitet je 23 ispitanika (57,5%). Faktori povezani sa povećanim mortalitetom su ženski pol (p = 0,008), kardiogeni šok (p = 0,025) i potreba za inotropnom stimulacijom tokom hospitalizacije (p = 0,000).
Zaključak: Akutni infarkt miokarda izazvan lezijom na glavnom stablu leve koronarne arterije je praćen visokom učestalošću kardiogenog šoka i stopom hospitalnog i kasnog mortaliteta. Uprkos visokoj stopi proceduralne uspešnosti perkutane procedure, mortalitet ovih bolesnika je i dalje visok.

Ključne reči:
akutni infarkt miokarda,
perkutana koronarna intervencija,
glavno stablo leve koronarne arterije

Introduction

Acute myocardial infarction caused by left main coronary artery stenosis or occlusion is a rare, but life-threatening event that occurs in 4 - 7% of patients presenting with acute myocardial infarction (AIM) (1). The main mechanism responsible for myocardial infarction is the rupture of an atherosclerotic plaque, or the formation of a thrombus, or both. Less common reasons can be embolus, aortic dissection or vasospasm (2). These patients are frequently presented with cardiogenic shock or cardiac arrest, and they are at high risk for in-hospital major cardiac adverse events (MACE). This clinical presentation is due to the fact that the left main coronary artery supplies ¾ of the myocardium with blood (3). These patients have a very bad prognosis, except if the reperfusion is performed as quickly as possible, or if they have very developed collateral circulation. The optimal revascularization strategy for unprotected left main coronary artery disease is the subject of an ongoing debate, especially in urgent settings, where the immediate optimal acute angiographic result is required to ensure the patient's survival and improve the prognosis. The advantages of percutaneous coronary intervention (PCI) are: that it is technically feasible in most patients, provides faster reperfusion compared to surgery and has acceptable short-term and long-term outcomes (4).

This study aims to investigate patient characteristics, procedural and clinical variables associated with favorable outcomes of percutaneous treatment, both in hospital and during a follow-up period.

Material and methods

A number of 40 patients with acute myocardial infarction who underwent PCI of the left main coronary artery (LM) were retrospectively reviewed, at the Clinic for Cardiology of The University Clinical Center of Serbia, from 1st January 2019 to 21st December 2022. The registry included demographic, clinical and angiographic characteristics. The patients and/or their families were contacted for a follow-up. The median follow-up period was 328.5 (range 1 - 1468) days.

Criteria for acute myocardial infarction were as follows: symptoms of acute myocardial ischemia, new ischemic ECG changes and elevated myocardial necrosis enzymes (5). The cardiogenic shock was defined as: hypotension (a systolic blood pressure of < 90 mm Hg for at least 30 minutes that requires supportive measures like inotropic drugs (dopamine, dobutamine, noradrenaline) or intra-aortic balloon pump (IABP), to maintain the systolic blood pressure of ≥ 90 mm Hg) and end-organ hypoperfusion (cool extremities or a urine output of < 30 ml per hour, and a heart rate of ≥ 60 beats per minute) (6). Significant stenosis of LM was defined as stenosis ≥ 50%, without bypass graft to the left anterior descending artery (LAD) or left circumflex artery (LCX) (7). Coronary flow was graded according to the TIMI (Thrombolysis in Myocardial Infarction) classification system. The procedure was considered successful if TIMI flow was 3 after the PCI procedure and/or stent implantation. All patients were hospitalized in intensive care units, where they received appropriate therapy. In-hospital mortality included all deaths that occurred during hospitalization.

Data were processed in SPSS software. Continuous variables were presented as mean ± standard deviation (SD). Categorical variables were presented as numbers or proportions. Categorical variables were compared using the chi-square test, and continuous variables were tested using the Student's t-test. As a statistically significant value, the value $p \leq 0.05$ was taken.

Results

Baseline demographic, clinical and echocardiographic characteristics of the patients

Baseline demographic and clinical characteristics of 40 patients with LM AIM are presented in **table 1**. The average age was 70.83 ± 11.415. A number of 31 patients (77.5%) had hypertension, 12 (30%) had prior AIM and PCI, and 5 patients (12.5%) had prior stroke. Fifteen patients (37.5%) had STEMI (ST-elevation myocardial infarction) and 25 patients (65.5%) had NSTEMI (non-ST-elevation myocardial infarction). Out of 20 patients who presented cardiogenic shock, 8 (40%) were STEMI and 12 (60%) were NSTEMI. A number of 23 patients (57.5%) required inotropic drug support to maintain their blood pressure at a normal range, and 4 patients (10%) required IABP. Ischemic time, the time from the moment when the symptoms started to the point when the infarcted left main artery was reopened, for most patients was within 3h (45%). The ejection fraction (LVEF) was evaluated after the PCI procedure and for 28 patients' average value was 36.61 ± 12.446%. The average ejection fraction in patients who died was 32.6 ± 12.13%, and for survivors was 40.06 ± 12.03% (p = 0.188).

Table 1. Baseline characteristics of study patients.

	n = 40
Age	70.83 ± 11.415
Sex	
male	26 (65%)
female	14 (35%)
Hypertension	31 (77.5%)
Diabetes mellitus	12 (30%)
Smoking	14 (35%)
Prior PCI	12 (30%)
Prior MI	12 (30%)
Prior stroke	5 (12.5%)
Cardiogenic shock	20 (50%)
IABP	4 (10%)
Ischemic time (h)	
0 - 3	18 (45%)
3 - 6	12 (30%)
6 - 12	9 (22.5%)
> 12	1 (2.5%)
LVEF % (mean ± SD) n = 28	36.61 ± 12.446
Inotropic support	23 (57.5%)
Maximum troponin level (ng/ml) n = 32	4798.69 ± 4143.860
STEMI	15 (37.5%)
NSTEMI	25 (62.5%)

PCI - Percutaneous coronary intervention; MI - Myocardial infarction; IABP - Intra-aortic balloon pump; LVEF - Left ventricular ejection fraction; STEMI - ST-elevation myocardial infarction; NSTEMI - non-ST-elevation myocardial infarction.

Angiographic data

Angiographic data are summarized in **table 2**, with LM stenosis as a culprit lesion in all patients, most often in the distal part (55%). About half of the study patients, 17 (42.5%), had 90 - 99% stenosis, but 6 (15%) patients had a complete occlusion. Only 8 (20%) patients had isolated LM stenosis, while other patients also had stenosis on other coronary arteries, including 5 (12.5%) patients who presented the three-vessel coronary artery disease. The most commonly affected coronary artery was the left anterior descending artery, in 25 (62.5%) patients. Pre-PCI TIMI flow in most patients was ≤ 2 (52.5%), but after the PCI procedure, 37 (92.5%) patients had TIMI 3 flow. A drug-eluting stent (DES) was used in all patients and 14 (35%) required ≥ 2 DES during the procedure.

Table 2. Angiographic data.

	n = 40
Location of LM disease	
proximal	17 (42.5%)
mid	1 (2.5%)
distal	22 (55%)
Pre-PCI TIMI flow	
0	7 (17.5%)
1	1 (2.5%)
2	13 (32.5%)
3	19 (47.5%)
Post-PCI TIMI flow	
0	0
1	1 (2.5%)
2	2 (5%)
3	37 (92.5%)
LM % stenosis	
50 - 69	7 (17.5%)
70 - 89	10 (25%)
90 - 99	17 (42.5%)
100	6 (15%)
Extent of coronary artery disease	
LM only	8 (20%)
LM + 1 vessel	7 (17.5%)
LM + 2 vessel	20 (50%)
LM + 3 vessel	5 (12.5%)
Total number of DES during procedure	
1	26 (65%)
≥ 2	14 (35%)
LAD stenosis	25 (62.5%)
RCA stenosis	17 (42.5)
LCX stenosis	19 (47.5%)

LM - Left main coronary artery; TIMI - Thrombolysis in Myocardial Infarction; DES - drug-eluting stent; LAD - left anterior descending artery; RCA - right coronary artery; LCX - left circumflex artery.

Outcomes

Outcomes are presented in **table 3**, and statistical analyses of clinical, demographic and angiographic variables are presented in **table 4** and **table 5**. The overall mortality was 57.5% (23 patients). Mortality in the catheterization laboratory was 5%, while in-hospital mortality reached 40%. Twenty-two patients were discharged after the hospital treatment. The median follow-up period was 328.5 (range 1 - 1468) days. Among hospital-discharged patients, the 1-year survival was 81.8%.

Statistical analyses showed that female gender (p = 0.008), cardiogenic shock (p = 0.025) and usage of inotropes (p = 0.000) correlated with increased mortality.

Table 3. Outcomes.

	n = 40
Death, total	23 (57.5%)
Catheterization laboratory mortality	2 (5%)
In-hospital mortality	16 (40%)
Median follow-up period (days)	328.5
Post-hospital mortality	5 (22.7%)
30-days mortality	19 (47.5%)
1-year mortality	22 (55%)

Discussion

In this retrospective analysis among the patients with AMI due to left main coronary artery stenosis treated with PCI, a high rate of in-hospital and long-term mortality was noted, despite the high rate of procedural and angiographic success of a primary PCI. Mortality was especially increased in female patients and if the clinical course was complicated with cardiogenic shock (CS) during the procedure or the hospitalization period.

The LM coronary artery disease presents a complex lesion subset due to its clinical significance and procedural technical complexity, especially in urgent presentations and during primary PCI. Patients with culprit lesions located on LM show a rapid decline and hemodynamic instability as their ischemic time prolongs. Therefore, for positive clinical outcome, it is necessary to perform optimal and prompt culprit lesion revascularization. Surgical revascularization is rarely performed in these situations of hemodynamic instability due to reperfusion delays and longer total ischemic time. Currently, primary PCI is the preferred type of revascularization in patients with LM stenosis and AIM. In the GRACE registry, which included patients from 2000 to 2007, the primary PCI procedure was the preferred therapeutic choice compared to surgery. During that period, rates of PCI increased from 18% to 40%, while surgical revascularization decreased from 45% to 20% (8).

In our study, in-hospital death occurred in 16 (40%) patients. Other reports such as those of Lee SW et al., Hurtado et al. and Tan et al. observed similar rates of mortality (9-11). Among our patients, CS was present in half of our patients and independently related to in-hospital and long-term mortality. Parma et al. also showed a high incidence of CS in their study (51.7%) (12). Also, compared to hemodynamically stable patients with AIM, CS is proven to be independently associated with mortality (10, 13). According to the literature, angiographic data, such as TIMI 0/1 flow, are known to be related to higher mortality, but in our population, this was not observed. The prevalence of TIMI 0/1 flow in our studied population was rather low (20%) when compared to the previously reported (4, 14). It is already shown by Homorodean et al. in their study that patients with TIMI 0/1 flow and absence of collateral circulation have less chance to present to the hospital and be treated with PCI (14). In our population, a longer total ischemic time was observed, compared to

Table 4. Statistical analysis of clinical and demographic data.

	DEATH		
	YES n = 23	NO n = 17	p
Sex			
male	11 (47.8%)	15 (88.2%)	**0.008**
female	12 (52.2%)	2 (11.8%)	
Hypertension	18 (78.3%)	13 (76.5%)	0.893
Diabetes mellitus	9 (39.1%)	3 (17.6%)	0.143
Smoking	6 (26.1%)	8 (47.1%)	0.169
Prior MI	6 (26.1%)	6 (35.3%)	0.530
Prior stroke	4 (17.4%)	1 (5.9%)	0.277
Cardiogenic shock	15 (65.2%)	5 (29.4%)	**0.025**
IABP	3 (13%)	1 (5.9%)	0.455
Inotropic drugs support	21 (91.3%)	2 (11.8%)	**0.000**
STEMI	7 (30.4%)	8 (47.1%)	0.283
NSTEMI	16 (69.6%)	9 (52.9%)	

MI - Myocardial infarction; IABP - Intra-aortic balloon pump; STEMI - ST-elevation myocardial infarction; NSTEMI - non-ST-elevation myocardial infarction.

Table 5. Statistical analysis of angiographic data.

	DEATH		
	YES n = 23	NO n = 17	p
Ischemic time (h)			
0 - 3	11 (47.8%)	7 (41.2%)	
3 - 6	6 (26.1%)	6 (35.3%)	0.565
6 - 12	6 (26.1%)	3 (17.6%)	
> 12	0	1 (5.9%)	
Location of LM disease			
proximal	11 (47.8%)	6 (35.3%)	0.448
mid	1 (4.3%)	0	
distal	11 (47.8%)	11 (64.7%)	
LM % stenosis			
50 - 69	2 (8.7%)	5 (29.4%)	
70 - 89	7 (30.4%)	3 (17.6%)	0.316
90 - 99	11 (47.8%)	6 (35.3%)	
100	3 (13%)	3 (17.6%)	
Extend of coronary artery disease			
LM	3 (13%)	5 (29.4%)	
LM + 1 vessel	2 (8.7%)	5 (29.4%)	0.111
LM + 2 vessel	14 (60.9%)	6 (35.3%)	
LM + 3 vessel	4 (17.4%)	1 (5.9%)	
Total number of DES during procedure			
1	14 (60.9%)	12 (70.6%)	0.524
≥ 2	9 (39.1%)	5 (29.4%)	
Pre-PCI TIMI flow			
0 - 2	11 (47.8%)	10 (58.8%)	0.491
3	12 (52.2%)	7 (41.2%)	
Post-PCI TIMI flow			
0 - 2	2 (8.7%)	1 (5.9%)	0.738
3	21 (91.3%)	16 (94.1%)	

LM - left main coronary artery; DES - drug-eluting stent; PCI - percutaneous coronary intervention; TIMI - thrombolysis in myocardial infarction.

other publications, since the majority of our population had TIMI ≥ 2 at presentation and therefore could clinically sustain longer ischemic periods. In our study, the majority of patients presented as NSTEMI (62.5%). Also, the STEMI rate was lower than expected for the AIM population with mortality risk being equal to patients presenting as NSTEMI. Jensen et al. demonstrated worse outcomes associated with STEMI presentation compared with those with NSTEMI in the population of patients with culprit lesions on LM (13). Contrary, Lee MS et al. found no statistically relevant difference in mortality between STEMI and NSTEMI patients (15). Higher rates of NSTEMI presentation and comparable outcomes to STEMI populations can be explained by the high ischemic relevance of LM lesions due to the large amount of jeopardized myocardium, even in the setting with relatively preserved flow (TIMI 2 - 3) as was observed in our population (80% of patients). As already known, female patients have a worse prognosis during AIM and following primary PCI. In our study, female gender was associated with higher mortality, while in Elmayergi et al. study, this wasn't observed, with men being the dominant gender in both populations (16).

In patients with acute LM occlusion, and hemodynamic instability, rapid blood pressure stabilization and urgent reperfusion are crucial for patients' survival. Blood pressure can be stabilized by drugs, but also with IABP. IABP implantation periprocedural and after intensive care stay has only minor hemodynamic effect, even if the main reason for that instability, acute LM occlusion, has been removed. In our study, IABP circulatory support (used in 10% of patients) did not affect survival. In the study of Thiele et al., also IABP did not reduce mortality during the follow-up period, and mortality rate remained very high for the patients with CS (17).

Study limitations

There were several limitations in this study. First and most importantly, the study population was small.

Second, given that this was a retrospective observational study, the enrolled patients were heterogeneous and residual confounding or selection bias cannot be completely excluded. Also, in this retrospective study, not all measurements were available for all patients and not all measurements were made at the same time intervals, for instance, ejection fraction. Although ejection fraction has been described as a predictor of mortality, the similar EFs in both groups of our study, rendered this a nonpredictive variable.

Conclusion

Acute myocardial infarction due to left main coronary artery stenosis is accompanied by a high incidence of cardiogenic shock and mortality. Primary percutaneous coronary intervention ensures faster reperfusion and improvement of the patient's condition compared to surgical revascularization, but despite the success of the percutaneous procedure, mortality remains very high, especially in women and patients with cardiogenic shock.

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