ORIGINAL ARTICLE

Association of coronary artery dominance and mortality rate and complications in patients with ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention

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Background: Percutaneous coronary intervention (PCI) is the treatment of choice for patients with ST-segment elevation myocardial infarction (STEMI). Effect of coronary artery dominance on the patients' outcome following primary PCI (PPCI) is not fully investigated. We investigated the association of coronary artery dominance with complications and 1-year mortality rate of PPCI. **Materials and Methods:** In this retrospective study, patients with STEMI treated with PPCI from March 2016 to February 2018 were divided into three groups based on their coronary dominancy: left dominance (LD), right dominance (RD), and codominant. Demographic characteristics, medical history, results of physical examination, electrocardiography, angiography, and echocardiography were compared between the groups. **Results:** Of 491 patients included in this study, 34 patients (7%) were LD and 22 patients (4.5%) were codominant. Accordingly, 54 propensity-matched RD patients were included in the analysis. The demographics and comorbidities of the three groups were not different ($P > 0.05$); however, all patients in the RD group had thrombolysis in myocardial infarction (TIMI) 3, while five patients in the LD and five patients in the codominant group had a TIMI ≤2 ($P = 0.006$). At admission, the median left ventricular ejection fraction (LVEF) was highest in RD patients and lowest in LD and codominant patients (34%, $P = 0.009$). There was no difference in terms of success or complications of PCI, in-hospital, and 1-year mortality rate ($P > 0.05$). **Conclusion:** Patients with left coronary artery dominance had a higher value of indicators of worse outcomes, such as lower LVEF and TIMI ≤ 2, compared with RD patients, but not different rates of success or complications of PCI, in-hospital, and 1-year mortality. This finding may suggest that interventionists should prepare themselves with protective measures for no-reflow and slow-flow phenomenon and also mechanical circulatory support before performing PPCI in LD patients.

Key words: Coronary circulation, coronary vessels, percutaneous coronary intervention, ST- segment elevation myocardial infarction

How to cite this article: Mikaeilvand A, Firuozi A, Basiri H, Varghaei A, Izadpanah P, Kojuri J, *et al.* Association of coronary artery dominance and mortality rate and complications in patients with ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention. J Res Med Sci 2020;25:107.

INTRODUCTION

Coronary heart disease (CHD), including coronary artery disease (CAD) and myocardial infarction (MI), is the leading cause of death worldwide.[1] According to the 2016 Heart Disease and Stroke Statistics update of the American Heart Association, 15.5 million people ≥20 years of age in the USA have had CHD, causing MI in one American every 42 s.[2] Recent

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Quick Response Code:

Website: www.jmsjournal.net

DOI: 10.4103/jrms.JRMS_414_19

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Submitted: 09-Sep-2019; **Revised:** 29-Apr-2020; **Accepted:** 13-Jul-2020; **Published:** 26-Nov-2020

advances in medical technology improved prognosis of patients with MI significantly;[3] however, patients with acute MI (AMI) have a 3-fold increased 1–3-year and 3–5-year mortality rate.[4]

Primary percutaneous coronary intervention (PPCI) is the treatment of choice, especially for patients with ST-segment elevation MI (STEMI),[5] which has significantly decreased the global 1-year case-fatality rate in the STEMI population.[6] However, percutaneous coronary intervention (PCI) may be associated with periprocedural complications and death.[7,8] Accordingly, research has focused on risk factors of 1-year mortality, suggesting that age, baseline left ventricular ejection fraction (LVEF), Killip class, heart rate, diabetes mellitus (DM), ischemia time, and anterior STEMI, or left bundle branch block, or/and 3-vessel CAD are the significant factors.[9,10]

Coronary artery dominance influences the amount and anatomic location of myocardium perfused by the left or right coronary circulation.[11,12] There are three types of coronary artery dominance: right, left, and balanced. Right dominance (RD), the most common type (about 70%–80%), refers to the origination of the arteries supplying the posterior interventricular septum from posterior descending artery and posterior lateral right coronary artery (RCA); left dominance (LD) refers to the origination of the arteries supplying the posterior interventricular septum from left circumflex artery (LCX), observed in about 8%–13% of cases; and codominance or balanced dominance refers to its origination from both from the RCA and LCX, observed in about 4%–18% of cases.[13] Coronary artery dominance is associated with the extent of CAD,[14,15] with incidence and all-cause mortality of AMI,[15,16] but not with atherosclerotic involvement.[17] Research has suggested difference in post-PCI outcome and mortality of patients with acute coronary syndrome (ACS) undergoing PCI based on their coronary artery dominance.[18-20] Coronary artery dominance is also associated with 30-day mortality and early reinfarction after STEMI.[21] Recent evidence also suggests worse clinical outcomes following PCI in LD patients with STEMI. Only few studies have addressed the association of coronary dominance with patient's outcomes following PCI.[12,22,23] According to the significance of this issue, we aimed to investigate a wide range of clinical, laboratory, and imaging parameters to study the effect of coronary artery dominance on post-PCI outcome, 1-year follow-up, and mortality rate in patients with STEMI.

MATERIALS AND METHODS

Study population

In this retrospective cross-sectional study, data from all the patients admitted with the diagnosis of STEMI undergoing PPCI from March 2016 to February 2018 at Rajaie Heart Center and Nemazee Hospital were gathered. From them, data of all LD or codominant patients were included. A sample of propensity-matched RD population was also included. The PPCIs were done by different interventions. The patients in the LD or codominant groups were included into the study by convenient sampling method, while the patients in the RD group were randomly included into the study using random permuted blocks.

Ethical consideration

The protocol of the study was approved by the local ethics committee, and all principles of the latest version of Helsinki's Declaration on human studies were met throughout the study. The ethical approval number is IR.SUMS.MED.REC.1396.S256.

Data extraction

All information was extracted from the patients' medical records. First, the coronary dominancy of patients was determined and the study samples were divided into three groups based on their coronary dominancy. Then, the demographics (age and sex), presence of symptoms (chest pain, dyspnea, pain site, and radiation), history of cardiopulmonary resuscitation before admission, history of MI, CAD, hypertension, DM, hyperlipidemia, smoking, and history of PCI and/or CABG were extracted from the patients' medical records. Further, the results of physical examination (jugular vein pressure measurement, cardiac auscultation, systolic and diastolic blood pressure, and pulse rate), results of laboratory tests including serum parameters, electrocardiography (EKG), angiography, and echocardiography, date of discharge, readmission, revascularization, and death were recorded and compared among the groups. The patients who had no record of readmission were contacted by telephone to ask if they had been admitted to other centers during this period.

PPCI was performed by an expert interventional cardiologist using Artis Zee Siemens (Siemens Health Care Co, Germany) by the conventionally approved procedures, and PCI success was defined as acquiring a thrombolysis in MI (TIMI) flow 3.

Statistical analysis

First, the normal distribution of data was tested by Kolmogorov–Smirnov test, which indicated that data were normally distributed and which were not. Therefore, the results of quantitative variables were presented by mean ± standard deviation (in cases with normal distribution) and by median and interquartile range. Data were compared by one-way ANOVA among the three groups of coronary artery dominance or by Mann–Whitney between patients with and without complication. The results of nominal or

ordinal variables were reported by frequency (percentage) and compared using Chi-square test. Echocardiographic procedural complications were reported by incidence index. Change in variables over time was tested by Friedman test. For the statistical analysis, the statistical software IBM SPSS Statistics for Windows version 21.0 (IBM Corp., 2018. Armonk, NY, USA: IBM Corp.) was used. $P < 0.05$ was considered statistically significant.

RESULTS

Patients

Of 491 patients included in this study, 34 patients (7%) were LD and 22 patients (4.5%) were codominant. Accordingly, 54 propensity-matched RD patients were randomly included in analysis to be comparable with other groups. Comparison of demographics among the three groups showed no difference in the mean age, sex distribution, frequency of symptoms, physical examination, and medical history of patients, as shown in Table 1.

Comparison of laboratory work-ups

Comparing the results of serum parameters showed statistically significant difference among the groups, only in fasting blood sugar (FBS), cardiac troponin-I (cTnI), and creatine kinase-MB (CK-MB) in LD patients ($P < 0.001$). Median FBS was 130.48 mg/dL in RD patients, 181.24 mg/dL in LD patients, and 116.47 mg/dL in codominant patients; the median cTnI was 3.15, 12.08, and 5.40 ng/mL, respectively; and CK-MB was 63.38, 195.79, and 87.16 U/L, respectively. However, other serum parameters including hemoglobin, white blood cells, platelet, C-reactive protein, creatinine, sodium, potassium, and cholesterol (total, low-density, and high-density lipoprotein) were not statistically different among the groups [Table 2].

Comparison of clinical work-ups

The results of EKG, echocardiography, and coronary angiography were compared among the three groups with different coronary artery dominance. As shown in Table 2, the results showed significant difference in the frequency of ST elevation, lower ST elevation of II and III leads in LD patients, and higher ST elevation in avF and right precordial leads in RD patients ($P < 0.05$). However, echocardiographic parameters were not different among the groups [Table 3], and significant difference was observed only in the value of ejection fraction (EF) at admission, which was significantly higher in RD group (34% vs. 40.3% in LD group and 33.8%

Table 1: Comparison of demographics and medical history among three groups of patients with different coronary artery dominancy

Variable	Category	Right dominant (%)	Left dominant (%)	Codominant (%)	*P*
Sex	Male	46 (85.2)	27 (79.4)	19 (86.4)	0.720*
	Female	8 (14.8)	7 (20.6)	3 (13.6)	
Age, mean±SD		58.74±8.63	57.59±9.55	62.52±12.11	0.175†
Chief complaint	Chest pain	53	34	21	0.281*
	Dyspnea	1	0	0	
	Others	1	0	1	
Pain site	Retrosternal	52	32	19	0.081*
	Left hemithorax	0	2	2	
	Back	0	0	2	
Pain radiation	Back	4	3	0	0.050*
	Left arm	29	14	3	
	Right arm	1	0	1	
	Abdomen	3	1	3	
CPR before admission	Positive	2	2	2	0.636*
History of CAD	Positive	4	3	3	0.691*
History of MI	Positive	2	1	1	0.951*
DM	Positive	14	11	4	0.499*
Hypertension	Positive	20	13	9	0.952*
Hyperlipidemia	Positive	17	12	5	0.605*
Smoking	Positive	28	12	10	0.312*
History of CA	Positive	12	4	5	0.425*
History of PCI	Positive	5	0	3	0.116*
History of CABG	Positive	4	0	2	0.232*
SBP (mmHg), mean±SD		129.28±3.39	123.60±4.08	126.95±4.51	0.560†
DBP (mmHg), mean±SD		81.44±2.18	79.79±3.05	81.45±3.32	0.889†
PR (/min), mean±SD		76.12±2.00	80.12±2.96	77.52±4.32	0.552†

*The results of Chi-square test; †The results of one-way ANOVA; CPR=Cardiopulmonary resuscitation; CAD=Coronary artery disease; MI=Myocardial infarction; DM=Diabetes mellitus; CA=coronary angiography; PCI=Percutaneous intervention; CABG=Coronary artery bypass graft; SD=Standard deviation; SBP=Systolic blood pressure; DBP=Diastolic blood pressure; PR=Pulse rate

Table 2: Comparison of median values of serum parameters among three groups of patients with different coronary artery dominancy

Variable	Right dominant	Left dominant	Codominant	*P**
Hemoglobin (g/dL)	16.89	14.32	14.70	0.575
WBC (count/mm^3)	10505.37	11925.29	11901.11	0.066
Platelet (count/mm^3)	221.31	225.94	218.94	0.899
ESR	16.25	16.73	11.27	0.381
HSCRP	4.40	15.87	5.86	0.096
Pre-PCI creatinine (mg/dL)	0.89	0.85	0.90	0.671
Sodium (mEq/L)	137.35	137.88	139.05	0.842
Potassium (mg/dL)	4.03	4.05	4.13	0.691
Cholesterol (mg/dL)	167.90	155.51	152.40	0.247
LDL	102.1154	92.93	91	0.299
HDL	44.15	37.88	41.39	0.379
FBS	130.48	181.24	116.47	<0.001
Pre-PCI cTnI, (ng/mL)	3.15	12.08	5.40	<0.001
Pre-PCI CK-MB, (U/L)	63.38	195.79	87.16	<0.001

*The results of ANOVA test; WBC=White blood cells; ESR=Estimated sedimentation rate; HS-CRP=High-sensitivity C-reactive protein; LDL=Low-density lipoprotein; HDL=High-density lipoprotein; FBS=Fasting blood sugar; cTnI=Cardiac troponin-I; CKMB=Creatine kinase-MB; PCI=Percutaneous intervention

in codominant group, $P = 0.009$). Comparing the results of coronary angiography also showed higher frequency of RCA involvement of > 90% in RD patients and higher frequency of RCA involvement of 70%–90% in co-dominant group [Table 3].

The results of PPCI showed no significant difference among the groups, as shown in Table 4 ($P < 0.05$); only, the frequency of TIMI flow 3 was significantly different among the groups ($P < 0.05$).

Comparing the data of the primary admission showed no significant difference among the groups in any parameters, such as death rate, cause of death, and time to death as well as the amount of stent restenosis, need for revascularization, and the prescribed drugs ($P > 0.05$) [Table 5]. Clinical outcomes at 1-year follow-up were not different according to the patients' coronary artery dominance [Table 5].

DISCUSSION

The results of comparing a wide range of clinical, laboratory, and imaging parameters between three groups (54 RD patients, 34 LD, and 22 codominant patients) with similar demographics and clinical/parameters showed the differences among them.

Of serum parameters, the median cTnI and CK-MB were significantly different, and the highest values were observed in LD group (12.08 ng/mL and 195.79 U/L, respectively), while the lowest values were observed in RD group (3.15 ng/mL and 63.38 U/L, respectively), and intermediate values were observed in codominant patients (5.40 ng/mL, and 87.16 U/L, respectively). Although, in this study, all the patients had a confirmed diagnosis of STEMI and were scheduled for PCI, the serum markers of ischemia were different according to coronary artery dominance. As these parameters have been suggested as important predictors of patients' outcomes following PCI,[24] the significant difference in the serum values of cTnI and CK-MB among patients with different coronary artery dominance is of great significance and suggests worse outcomes following PCI in LD patients. Furthermore, patients' LVEF at admission (before PPCI) was also different and was highest in RD patients (40%) and lowest in LD and co-dominant patients (34%), which also implies worse patients' outcomes in LD patients, compared with RD patients. Previous studies have stated that LVEF was an important predictor of worse clinical outcome in LD patients; however, they have also referred to a higher mortality rate in LD patients.[21,25,26] However, in the present study, the results of the PPCI and 1-year follow-up were not significantly different among the groups. This discrepancy could be related to several factors, including differences in demographics of patients (such as age and sex distribution) and cardiac characteristics of MI in the patients. As shown in the results of this study, EKG assessment showed differences in the ST elevation of different cardiac leads and the results of echocardiography also showed some differences in the percentage of involvement of arteries such as RCA, which could affect the patients' outcomes. Another factor for lack of significant difference in death rates, cause of death, and time to death in our study could be because of the small number of patients who died during our study period, as there were only five patients in total with in-hospital death and only one with death during the 1-year follow-up.

Several parameters were investigated in the present study for the assessment of patients' outcomes following PCI. Most importantly, parameters related to the PPCI were investigated, and the results showed that PCI success and complications were not different among the groups with

Table 3: Comparing the results of electrocardiography, echocardiography, and coronary angiography among the three groups with different coronary artery dominance

Variable	Subcategories	Right dominant	Left dominant	Co-dominant	*P*
Electrocardiography					
Rhythm	Sinus	52	33	18	0.111*
	Atrial fibrillation	1	1	1	
	Ventricular	0	0	2	
	Junctional	1	0	1	
Atrioventricular block	None	47	31	18	0.698*
	1st degree	6	3	4	
	2nd degree	0	0	0	
	CHB	1	0	0	
ST elevation	I	5	11	5	0.024†
	II (mm)	1.16	0.55	1.04	0.111†
	III (mm)	1.73	0.91	1.36	0.104†
	avR	0	1	2	0.087*
	avL	3	6	5	0.040*
	avF	28	5	9	0.002*
	V1-V3 (mm)	0.50	0.50	0.45	0.985†
	V2-V4 (mm)	0.31	0	0	0.173†
	V1-V6 (mm)	2.01	1.29	1.68	0.897
	V5-V6 (mm)	0.30	0.32	0.09	0.668
	Right	9	2	3	0.056*
	Posterior	2	1	1	0.951*
Echocardiography					
Left ventricle size	Normal	51	32	21	0.976*
	Enlarged	3	2	1	
Ejection fraction categories	≥55%	3	0	1	0.442*
	45-54%	11	6	4	
	35-44%	26	19	11	
	21-34%	13	5	3	
	≤20%	1	4	3	
Ejection fraction (%), median		40.28	34.00	33.80	0.009
Right ventricle size	Normal	52	31	21	0.576*
	Enlarged	2	3	1	
RV function	Normal	37	24	16	0.647*
	Mild or moderate dysfunction	17	9	6	
	Severe dysfunction	0	1	0	
Mitral regurgitation		18	3	5	0.31*
Diagnosis					
Left main lesion		1	0	0	0.530*
Single-vessel disease		22	13	7	
2-vessel disease		13	13	5	
Multivessel disease		18	8	10	

*The results of Chi-square test; †The results of one-way ANOVA; IVCD=LAFB; Left anterior fascicular block; LPFB=Left posterior fascicular block; LBBB=Left bundle branch block; RBBB=Right bundle branch block; RV=Right ventricular; CHB=Complete heart block

different coronary dominance. The only PCI parameter with significant difference among the groups was TIMI 3, as all the RD patients had TIMI 3, while 29 LD patients had TIMI 3 (four had TIMI 2 and one had TIMI 1); in codominant group, 16 had TIMI 3 and five had TIMI 2. TIMI can show the myocardial perfusion[27] and is an important prognostic value and patients' risk.[28] Patients with TIMI 3 are suggested to have a better in-hospital mortality rate, LVEF, prehospital fibrinolytic therapy, cardiogenic shock, and use of intra-aortic balloon pump compared with patients with TIMI ≤2.[29,30] In the present study, all RD patients had TIMI 3, while a number of LD and codominant patients had TIMI ≤2, which implies better outcome in RD patients. Achieving TIMI 3 is one of the main goals of PCI, failure to achieve TIMI 3 is suggested as a predictor of mortality after PPCI,[31] and association of TIMI scores with coronary artery dominance in the present study shows the significance of coronary artery dominance in patients' outcomes.

Table 4: Comparison of the results of primary percutaneous intervention among three groups of patients with different coronary artery dominancy

Variable	Category	Right dominant	Left dominant	Co-dominant	*P*
Culprit vessel	Left main	1	0	0	0.594*
	Left anterior descending	21	17	8	
	Left circumflex artery	5	4	4	
	Right coronary artery	17	4	5	
	Ramus intermedius	1	0	0	
	Diagonal	0	0	1	
	Obtuse marginal	4	7	3	
	Left anterior descending + right coronary artery	1	0	0	
	Left anterior descending + ramus intermedius	0	1	0	
	Saphenous vein graft	4	1	1	
PCI results	Successful	54	33	21	0.341*
	Failed	0	1	1	
TIMI after PCI	0	0	0	1	0.006*
	1	0	1	0	
	2	0	4	5	
	3	54	29	16	
PCI complications	No reflow	0	0	1	0.110*
	Rupture	0	1	0	
	Dissection	0	0	1	
Need to urgent surgery		0	0	1	0.133*
Stent size (mm), median		22.83	24.36	23.95	0.674†
Stent type	Drug-eluting stent	52	30	21	0.810*
	Bare metal stent	2	0	1	
Double stent		13	6	4	0.066*
Triple stent		5	2	0	0.054*
Door to balloon (min)		63.05	169.05	51.71	0.099†

*The results of Chi-square test; †The results of One way ANOVA. PCI=Percutaneous intervention; TIMI=Thrombolysis in myocardial infarction

A closer look into the literature shows that only few studies have addressed the association of coronary dominance with patient's outcomes following PCI, and the results of these studies are also controversial. Parikh *et al.* showed significantly worse in-hospital mortality rate in LD patients undergoing PCI because of ACS.[19] Goldberg *et al.* also indicated LD as a significant and independent predictor of worse long-term mortality in patients with ACS.[32] Considering patients with STEMI, Veltman *et al.* studied 1131 patients with acute STEMI treated with PPCI and showed that LD patients had a worse 30-day mortality rate, compared with RD patients, but similar mortality rate after 30 days.[21] However, the study by Abu-Assi *et al.* showed a higher risk of death and reinfarction in LD patients, compared with RD patients.[26] The worse patients' outcomes in these studies are suggested to be because of the lager caliber of circumflex artery and the higher risk of mortality in patients with occlusion of the proximal circumflex artery.[33] In our study, although TIMI and LVEF were different among the patients with different coronary dominance, which implied worse outcomes in LD patients, we did not find any difference in the in-hospital or 1-year mortality rate. Similar to our results, Lam *et al.* also reported no association between coronary dominance and mortality rate, treatment failure, or major adverse cardiac events; however, they indicated different periprocedural MIs.[25]

There were also some findings in the results of the present study that we could not justify. One of the these serum parameters with significant difference among the groups was FBS, with highest in the LD patients followed by the RD patients and lowest in the codominant patients (181.24, 130.48, and 116.47 mg/dL, respectively). This difference should be a random finding and diabetes is not supposed to be related to coronary artery dominance. However, it was notable that the median FBS value was high in all the groups, although only 14, 11, and 4 patients had a positive history of diabetes. This finding confirms the results of previous studies on the association of diabetes with occurrence of STEMI and the infarct size.[34] It also confirms that most Iranian patients are unaware of their diabetes,[35] which is of greater significance in patients with CVD.

The present study included a wide range of variables and reported in-hospital and 1-year complications and mortality rate of patients with STEMI following PCI. However, this study could have some limitations. The first limitation is related to the retrospective nature of the study, which increased the risk of bias in the recorded data. To address

Table 5: Comparison of the clinical outcomes of patients among three groups with different coronary artery dominancy in their first admission

Variable	Category	Right dominant	Left dominant	Codominant	*P**
Complete relief of chest pain		48	27	16	0.242
Complete relief of ST elevation		43	22	14	0.173
Post-PCI cTnI		8.12	15.42	12.01	0.059
Post-PCI creatinine		0.90	0.96	0.95	0.639
Post-PCI hemoglobin		16.44	13.38	12.99	0.627
Death		1	2	2	0.352
Death time	During percutaneous intervention	1	1	0	0.335
	24 h after PCI	0	0	1	
	More than 24 h after PCI	0	1	1	
Cause of death	Cardiogenic shock	1	2	1	0.352
	Arrhythmia	0	0	0	–
	Others	0	0	1	0.133
Need to reangiography		4	0	2	0.232
Cause of reangiography	New chest pain	0	0	1	0.265
	Chest pain not relieved	1	0	0	
	Arrhythmia	0	0	1	
	Echocardiographic changes	1	0	0	
	Stage PCI	2	0	0	
Change in reangiography	No change	2	0	2	0.379
	Previous site	1	0	0	
	New site	1	0	0	
Previous stent	Patent	3	0	2	0.433
	>50 restenosis	1	0	0	
Discharge without complete cure		5	5	7	0.054

*The results of Chi-square test. PCI=Percutaneous intervention; cTnI=Cardiac troponin-I

this limitation, we confirmed the recorded data by calling the patients through telephone. The second limitation of this study was related to the wide range of parameters that can affect the patients' outcomes following PCI, such as age and cardiac characteristics, which could not be controlled in this study, although demographic characteristics of the patients were similar among the study groups. Furthermore, we had no tool to assess the infarct size which is very important prognostic factor, and many of our findings can be explained with this parameter.[32]

CONCLUSION

Coronary artery dominance influences the myocardial perfusion, and the results of the present study showed that patients with LD and codominant coronary arteries had a higher frequency of TIMI ≤ 2, compared with RD patients, which confirms better perfusion in the RD patients. Further, this group of patients (RD) had a higher LVEF, compared with patients with LD and codominant coronary arteries. However, studying PCI parameters showed indifferent rates of success or complications of PCI and no difference in terms of in-hospital and 1-year mortality. These results could be because of the effect of confounders or small sample size. Furthermore, there are very few studies addressing this issue, which have reported dissimilar results. This finding may suggest that interventionists should prepare themselves with protective measures for no-reflow and slow-flow phenomenon and also mechanical circulatory support before performing PPCI in LD patients. Accordingly, we suggest that further studies investigate the effect of coronary artery dominance and patients' outcomes following PCI, especially in patients with STEMI.

Acknowledgments

The authors of the present study sincerely thank Dr. Mohammad Pourmontaseri for his contribution in the preparation of this manuscript. The ethical approval number is IR.SUMS.MED.REC.1396.S256.

Financial support and sponsorship

The present study was financially supported by two grants; one from Rajaei Heart Hospital and the other (Grant No. 95-01-01-13421) from Vice Chancellery for Research Affairs, Shiraz University of Medical Sciences.

Conflicts of interest

There are no conflicts of interest.

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