Original paper

Prognostic significance of small vessel coronary artery disease in patients with acute coronary syndromes treated with percutaneous coronary interventions

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Abstract

Introduction: Small vessel disease (SVD) usually refers to atherosclerosis within vessels of diameter of < 2.5 mm. Conflicting data exist regarding the outcomes of its revascularization.

Aim: To evaluate the outcome of invasive treatment in patients with acute coronary syndromes (ACS) and SVD and the predictors of angina recurrence after percutaneous coronary intervention (PCI).

Material and methods: This was an observational, retrospective, single-center study. It covered consecutive 127 patients (26.77% women; median age: 69.74 ±8.97 years) with ACS who underwent PCI in the Upper-Silesian Medical Center in Katowice between 2018 and 2020. The study population was stratified by means of presence of SVD defined by PCI of the culprit artery with a diameter of ≤ 2.5 mm. The major adverse cardiac and cerebrovascular events (MACCE) and angina recurrence were analyzed in a 12-month follow-up period.

Results: Overall 99 (77.95%) patients were diagnosed with small-vessel coronary artery disease. MACCE were documented in 14 (11.02%) patients. Univariate analysis revealed the following factors associated with MACCE: left ventricle ejection fraction (LVEF) (OR = 0.95, p = 0.0212), left main (LM) stenting (OR = 18.17, p = 0.0216), number of former PCIs (OR = 1.48, p = 0.0235). According to logistic regression analysis the factors were LM stenting (OR = 20.04, p = 0.0216) and number of former PCIs (OR = 1.53, p = 0.0203). Patients with SVD had more often refractory or recurrent angina in symptomatic class III/IV on follow-up (52.53% vs. 10.71%, p < 0.001).

Conclusions: Outcome of invasive treatment in patients with ACS is related to LM stenting and former PCIs but not to SVD occurrence. Patients with SVD have a high rate of recurrent/refractory angina despite successful PCI in this clinical setting.

Key words: small vessel coronary artery disease, acute coronary syndrome, percutaneous coronary intervention, major adverse cardiac and cerebrovascular events, recurrent angina, refractory angina.

Summary

Taking into consideration the clinical importance of small vessel coronary artery disease (SVD), the data on SVD revascularization outcomes and percutaneous coronary intervention (PCI)-related major adverse cardiac and cerebrovascular events risk factors are still scarce. Since the aim of our study was to evaluate the outcome of invasive treatment of patients with acute coronary syndrome diagnosed with SVD and the predictors of angina recurrence after PCI, our findings may help to improve the clinical management of patients undergoing PCI. Our investigations demonstrated that presence of SVD does not seem to be associated with long-term outcome in patients subject to PCI. Additionally, patients with SVD have a higher rate of recurrent or refractory angina; thus it is vital for proper anti-anginal pharmacotherapy to be provided by clinicians.

Introduction

Coronary artery disease (CAD) is one of the leading causes of morbidity and mortality worldwide [1]. The manifestations of CAD involve both asymptomatic and symptomatic ones such as stable and unstable angina, myocardial infarction and sudden cardiac death [2]. Traditional cardiovascular risk factors can be categorized into non-modifiable, such as sex and age, and modifiable such as arterial hypertension, dyslipidaemia, obesity, diabetes mellitus and smoking [3].

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Coronary atherosclerosis is a dynamically evolving inflammatory disease associated with development of atherosclerotic plaque and arterial wall remodeling. Therefore, the treatment of coronary atherosclerosis comprising management of artherosclerotic plaque should be undertaken to prevent progression or rupture of the plaque, facilitate its regression or prevent ischemia and sudden cardiac death, and alleviate angina pectoris [4]. The therapy includes pharmacological treatment and myocardial revascularization, including percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG), which lead to alleviation of symptoms and improved long-term survival in a specific patient subset [1]. Still, myocardial revascularization is limited by many factors, including small vessel size [1].

Small vessel (< 2.5 mm) coronary artery disease (SVD) refers to the range of coronary microcirculation disorders, which is mainly prevalent among patients afflicted by chronic conditions, such as chronic kidney disease (CKD), diabetes mellitus (DM) as well as nicotine dependency [5]. Despite numerous attempts at retrospective analysis of the clinical significance of SVD, there is a paucity of data regarding the outcome of revascularization concerning vessels < 2.5 mm. This clinical challenge is further complicated by the heterogenous definition of SVD. Thus the exact epidemiology of SVD is not well known [6, 7]. It is suggested that SVD is present in more than 30% of patients suffering from chronic coronary syndrome and is more prevalent among females [7, 8].

Taking into consideration the results of SVD treatment, this disease is associated with a higher risk of restenosis, late lumen loss and adverse effects of PCI; however, it does not seem to affect the risk of target lesion thrombosis, myocardial infarction (MI), and all-cause death [6]. Current treatment options for SVD include drug-eluting stents (DES), drug-eluting balloons (DEB) and plain old balloon angioplasty (POBA); however, the latter is linked to higher restenosis risk because of elastic recoil and adverse remodeling [9]. Moreover, recent research revealed that DEB use is associated with higher risk of restenosis compared to DES [6].

Aim

The aim of the present study was to evaluate the outcome of invasive treatment of patients with acute coronary syndromes (ACS) diagnosed with small vessel coronary artery disease, according to the usage of different techniques of PCI, and to evaluate the predictors of angina recurrence after PCI.

Material and methods

This was an observational, retrospective, single-center study. It covered 127 consecutive patients with ACS (unstable angina – n = 37, 29.1%, non-ST elevation myocardial infarction (NSTEMI) – n = 67, 52.8% ST elevation myocardial infarction (STEMI) – n = 23, 18.1%) who underwent the PCI procedure in the Upper Silesia Medical Center in Katowice, Poland, between 2018 and 2020. The data were acquired following meticulous analysis of electronic health records.

The mandatory inclusion criteria comprised acute coronary syndrome referred for coronary angiography and PCI. The main exclusion criterion was no indication for PCI during index coronary angiography, indications for surgical revascularization, active neoplastic disease, age at enrollment < 18 or > 85 years, and severe valvular heart disease.

All the study participants gave their written informed consent for study enrollment. The study was carried out in accordance with the Declaration of Helsinki and the study protocol was accepted by the Ethics Committee of the Medical University of Silesia in Katowice.

The collected data comprised clinical characteristics, such as sex, age, body mass index (BMI) as well as presence of diabetes mellitus and insulin therapy, hypertension, hyperlipidemia, atrial fibrillation, history of myocardial infarction and PCI or/and CABG, restenosis, family history of cardiovascular disorders, oncological history, and transthoracic echocardiography with left ventricular ejection fraction. We also included procedural characteristics of the PCI procedure: culprit artery, diameter of arteries, length and diameter of lesions, periprocedural MI, length and type of the stent, periprocedural artery occlusion and perforation.

The patients were categorized based on the vessel size (≤ 2.5 mm – SVD and > 2.5 mm) and the presence of a composite end-point of major adverse cardiovascular and cerebrovascular events (MACCE) or refractory or recurrent angina of Canadian Cardiovascular Society class 3 or 4 on follow-up.

The primary composite endpoint involved MACCE defined as occurrence of death, urgent myocardial revascularization or stroke. The secondary endpoints comprised the components of the primary composite endpoint, presence of restenosis in the culprit artery, quality of life, and severity of angina pectoris according to the CCS scale.

The follow-up study was carried out from August 2021 to December 2021. It was based on questionnaires given to patients with the diameter of the stented artery both ≤ 2.5 mm and > 2.5 mm. The survey included questions about: 1) time since PCI (< 1 or > 1 year); 2) readmission to cardiology unit since PCI; 3) cause of readmission; 4) PCI/CABG since the last PCI; 5) well-being on a scale from 1 to 5; 6) severity of angina pectoris (CCS grading) after PCI; 7) deaths, 8) occurrence of MACCE. In the case of lack of contact with the patient, the follow-up was completed using the analysis of healthcare provider data and electronical health records. All the data were gathered anonymously so that individual cases could not be identified.

Statistical analysis

The distribution of continuous variables was verified using the Shapiro-Wilk test. Continuous variables were expressed as arithmetic mean ± standard deviation (SD) or median and 1-3 quartile boundary, whereas categorical variables were shown as absolute counts with percentages (%). In the case of continuous variables, the Mann-Whitney test or Kruskal-Wallis test was applied, while in the case of qualitative parameters the χ^2 test was utilized. Univariable odds ratios with 95% confidence intervals (95% CI) were calculated for prediction of the presence of MACCE. Subsequently, all the parameters with $p < 0.1$ were incorporated into the stepwise multivariable logistic regression model in order to establish the independent predictors of MACCE. A receiver operating characteristics curve for the model was plotted. A two-sided *p*-value of 0.05 was considered statistically significant.

Results

The analysis covered 127 patients (99 of whom were diagnosed with small vessel coronary artery disease) with a mean age of 69.74 ±8.97 years, weight of 83.33 ±19.45 kg and height of 167.98 ±9.32 cm. The study population included 93 (73.23%) men and 34 (26.77%) women with a mean BMI of 30.47 ±4.36 kg/m^2 and left ventricular ejection fraction (LVEF) of 46.56 ±12.64%.

The study group characteristics are presented in Table I. The comparison of different clinical variables between the group without SVD (> 2.5 mm) and with SVD (< 2.5 mm) is highlighted in Table II. The analysis revealed that patients with SVD had significantly higher body weight and non-significantly higher BMI and number of former PCI procedures, more often suffered from NSTEMI and less often from unstable angina (UA) (p = 0.001), more often underwent chest radiation therapy

Table I. Baseline characteristics and periprocedural variables of the study population

Variable	*n* (%) or Mean ± SD
Baseline characteristics:	
Male	93 (73.23)
Age [years]	69.74 ±9.0
BMI [kg/m^2]	30.47 ±4.4
Diabetes mellitus	48 (38.71)
Hypertension	110 (87.30)
Hyperlipidemia	97 (78.86)
Atrial fibrillation	21 (16.54)
Current smoker	30 (24.39)
Previous MI	57 (45.60)
Previous PCI	66 (53.23)
Previous STEMI	29 (24.37)
Previous NSTEMI	29 (24.37)
Previous CABG	26 (20.80)
Restenosis	20 (16.00)
Use of statins	104 (83.87)
Use of β-blockers	98 (79.67)
Use of ACEI/ARB	100 (81.97)
Use of MRA	32 (26.02)
UA	37 (29.1)
NSTEMI	67 (53.60)
STEMI	23 (18.55)
Npl in past	15 (12.10)
History of chest radiotherapy	12 (9.92)
Cardiac arrest before PCI	8 (6.45)
LVEF (%)	46.56 ±12.6
Hemoglobin [g/dl]	13.42 ±2.0
eGFR [ml/min/1.73 m^2]	67.36 ±21.4

Variable	*n* (%) or Mean ± SD
Periprocedural data:	
Volume of contrast [ml]	147.16 ±58.9
Length of the lesion [by balloon/stent]	21.37 ±11.4
Baseline TIMI	2.96 ±0.2
LM disease	3 (2.42)
DES	104 (83.87)
DEB	11 (8.80)
BMS	5 (4.00)
POBA	8 (6.45)
Diameter of the artery [mm]:	
< 1.5	5 (3.94)
1.5–2.0	2 (1.57)
2.0–2.5	92 (72.44)
> 2.5	28 (22.05)
Small vessel disease (< 2.5 mm)	99 (77.95)
Coronary perforation	1 (0.80)
Artery occlusion	12 (9.52)
Periprocedural MI	3 (2.38)
Periprocedural complications	14 (11.02)
Follow-up:	
CCS scale	2.70 ±0.7
Wellbeing self-assessment [1–5]	3.46 ±1.0
Re-hospitalization in the cardiology department after PCI	18 (14.17)
PCI on follow-up	10 (7.87)
Death	5 (3.94)
Ischemic stroke	1 (0.79)
MACCE	14 (11.02)

Data are presented as number and percentage (in brackets) of patients or mean ± standard deviation. BMI – body mass index, MI – myocardial infarction, PCI – percutaneous coronary intervention, STEMI – ST-segment-elevation myocardial infarction, NSTEMI – non-ST-elevation myocardial infarction, CABG – coronary artery bypass graft, CAD – coronary artery disease, ACEI – angiotensin-converting enzyme inhibitors, ARB – angiotensin II receptor blockers, MRA – mineralocorticoid receptor antagonists, UA – unstable angina, Npl – neoplasm, LVEF – left ventricular ejection fraction, TIMI – Thrombolysis In Myocardial Infarction, eGFR – estimated glomerular filtration rate, LM – left main coronary artery, DES – drug-eluting stent, DEB – drug-eluting balloon, POBA – plain old balloon angioplasty, CCS – Canadian Cardiovascular Society grading scale, MACCE – major adverse cardiovascular events.

Table II. Demographic and clinical characteristics in patients with and without small vessel coronary disease (SVD)

Variable	SVD– (> 2.5 mm) *N* = 28	SVD+ (≤ 2.5 mm) *N* = 99	*P*-value
Baseline characteristics:			
Male	22 (78.57%)	71 (71.72%)	0.470
Age [years]	69.6 ±9.0	70.21 ±9.2	0.573
BMI [kg/m^2]	29.92 ±4.2	32.25 ±5.1	0.569
Obesity	13 (68.42%)	22 (30.99%)	0.003
Diabetes mellitus	11 (39.29%)	37 (38.54%)	0.943
Arterial hypertension	26 (92.86%)	84 (85.71%)	0.317
Hyperlipidemia	23 (88.46%)	74 (76.29%)	0.177
Atrial fibrillation	6 (21.43%)	15 (15.15%)	0.430
Current smoker	8 (28.57%)	22 (23.16%)	0.558
Previous MI	10 (35.71%)	47 (48.45%)	0.233
Previous STEMI	6 (22.22%)	23 (25.00%)	0.768
Previous NSTEMI	6 (22.22%)	23 (25.00%)	0.768
Number of former PCIs	10 (37.04%)	56 (57.73%)	0.057
Previous CABG	4 (14.29%)	22 (22.68%)	0.335
Previous restenosis	3 (10.71%)	17 (17.53%)	0.386
Family history of CAD	3 (10.71%)	22 (26.19%)	0.089
Use of statins	24 (85.71%)	80 (83.33%)	0.763
Use of β-blockers	25 (89.29%)	73 (76.84%)	0.15
Use of ACEI/ARB	21 (77.78%)	79 (83.16%)	0.649
Use of MRA	5 (17.86%)	27 (28.42%)	0.263
UA	24 (85.71%)	13 (13.1%)	< 0.001
NSTEMI	9 (32.14%)	58 (59.79%)	0.010
STEMI	3 (10.71%)	20 (20.83%)	0.225
Npl in past	2 (7.14%)	13 (13.54%)	0.361
History of chest radiotherapy	0 (0.00%)	12 (12.90%)	0.045
Cardiac arrest before PCI	0 (0.00%)	8 (8.33%)	0.114
LVEF [%]	45.32 ±13	50.79 ±10.4	0.023
TIMI grade	2.96 ±0.2	2.96 ±0.2	0.909
Hemoglobin [g/dl]	13.27 ±2.1	13.95 ±1.8	0.170
eGFR [ml/min/1.73 m^2]	66.25 ±21.3	71.21 ±21.5	0.280
Periprocedural data:			
Volume of contrast [ml]	143.04 ±56.7	160.09 ±64.9	0.376
Length of the lesion [by balloon/stent]	21.78 ±12.1	21.57 ±8.9	0.730
LM disease	0 (0.00%)	3 (3.13%)	0.344
DES	27 (96.43%)	77 (80.21%)	0.040
DEB	1 (3.57%)	10 (10.31%)	0.268
BMS	0 (0.00%)	5 (5.15%)	0.220
POBA	8 (8.42%)	0 (00.00%)	0.517
Coronary perforation	0 (0.00%)	1 (1.03%)	0.590
Artery occlusion	1 (3.57%)	11 (11.22%)	0.224
Periprocedural MI	0 (0.00%)	3 (3.06%)	0.349
Periprocedural complications	1 (3.57%)	13 (13.13%)	0.154

Table II. Cont.

Variable	SVD– (> 2.5 mm) *N* = 28	SVD+ (≤ 2.5 mm) *N* = 99	*P*-value
Follow-up:			
Readmission to cardiology department after PCI	3 (10.71%)	15 (15.15%)	0.552
CCS III–IV	3 (10.71%)	52 (52.53%)	< 0.001
Wellbeing self-assessment [1–5]	3.41 ±1.0	3.58 ±0.9	0.666
Urgent PCI on follow-up	2 (7.14%)	8 (8.08%)	0.871
Ischemic stroke	0 (0.00%)	1 (1.01%)	0.593
Death	0 (0.00%)	5 (5.05%)	0.225
MACCE	2 (7.14%)	12 (12.12%)	0.458

Data are presented as number and percentage (in brackets) of patients or mean ± standard deviation. BMI – body mass index, DM – diabetes mellitus, MI – myocardial infarction, PCI – percutaneous coronary intervention, STEMI – ST-elevation myocardial infarction, NSTEMI – non-ST-elevation myocardial infarction, CABG – coronary artery bypass graft, CAD – coronary artery disease, ACEI – angiotensin-converting enzyme inhibitors, ARB – angiotensin II receptor blockers, MRA – mineralocorticoid receptor antagonists, UA – unstable angina, Npl – neoplasm, LVEF – left ventricular ejection fraction, TIMI – Thrombolysis In Myocardial Infarction, eGFR – estimated glomerular filtration rate, DES – drug-eluting stent, DEB – drug-eluting balloon, POBA – plain old balloon angioplasty, CCS – Canadian Cardiovascular Society grading scale, MACCE – major adverse cardiovascular events.

(p = 0.045), and had greater LVEF (p = 0.023). The right coronary artery was stented more often among patients without SVD (p = 0.010). Of note, patients with SVD had more often refractory or recurrent angina in symptomatic class III/IV on follow-up (p < 0.001). There was no statistically significant difference in wellbeing self-assessment between SVD+ and SVD- groups. MACCE were documented in 12 (12.12%) patients of the SVD(+) group vs. 2 (7.14%) patients of the SVD(-) group (Table II).

The median follow-up time was 12 months. MACCE were documented in 14 (11.02%) patients. Five (3.94%) patients died, 1 (0.79%) patient exhibited ischemic stroke, while 10 (7.87%) patients required urgent myocardial revascularization. No in-hospital deaths or other MACCE were reported. The comparison of patients who had MACCE is presented in Table III. Canadian Cardiovascular Society (CCS) Angina Score class III and IV was more frequent in the MACCE+ group, but this difference did not reach statistical significance.

Univariate analysis revealed that the following factors were associated with MACCE: LVEF (OR = 0.95, p = 0.0212), LM stenting (OR = 18.17, p = 0.0216) and number of former PCIs (OR = 1.48, p = 0.0235). According to logistic regression analysis, LM stenting (OR = 20.04, p = 0.0216) and number of former PCIs (OR = 1.53, p = 0.0203) were associated with the onset of MACCE. Results of univariate analysis and logistic regression analysis are presented in Table IV.

Discussion

Our results provide data on demographic and clinical characteristics in patients with SVD undergoing PCI, the outcomes of the invasive treatment and subsequent occurrence of MACCE. In our population, SVD was revealed in 77.95% of patients, which is consistent with estimations in the review by Berry *et al.* [7]. The mentioned research paper suggests that SVD may be present in more than 1 in 3 stable patients presenting with anginal chest pain. Our findings do not correspond with research by Patel *et al.*, which suggested that SVD is more common in women [8]. In our study no correlation between gender and SVD presence was found. According to the results of former studies, PCI of small vessels has been associated with poor short-term outcomes in regard to myocardial infarction, vessel dissection or acute vessel closure [10, 11]. However, Dan *et al.* [12] in a study comparing the immediate outcomes of PCI in small vessels with those in large vessels, on a group of 100 patients, observed successful periprocedural outcomes with a negligible rate of complications. Our results found clear support for those findings.

Although previous data provided evidence for a higher rate of restenosis in patients with SVD subject to PCI, our study did not provide data to support it [5]. While restenosis was more common in patients with SVD, the difference did not reach statistical significance. According to the literature, the introduction of DES significantly reduced the incidence of restenosis [6, 10]. The high success rate and low risk of restenosis with the use of DES may be responsible for high utilization of DES in arteries with small vessel size, with POBA being in second place. Although one should be aware of the increased risk of restenosis in smaller diameter vessels, this phenomenon may be negligible in contemporary clinical practice given the advent of second generation DES.

According to our study, our follow-up did not reveal any other differences in long-term outcomes in patients with and without SVD. Although no association between SVD and MACCE was found, the study revealed a higher rate of refractory angina of CCS class III/IV in patients with SVD. SVD is often diffuse and PCI of a single coronary vessel might not yield symptomatic relief. Coronary atherosclerosis within small coronary vessels can lead to debilitating angina and impaired quality of life. Thus, an-

Table III. Demographic and clinical characteristics in patients with and without major adverse cardiovascular events on follow-up

Variable	No MACCE *N* = 113	MACCE *N* = 14	*P*-value
	n (%) or mean ± SD	*n* (%) or mean ± SD	
Baseline characteristics:			
Male	82 (72.57)	11 (78.57)	0.632
Age [years]	69.77 ±8.6	69.50 ±11.7	0.568
Obesity	32 (38.55)	3 (42.86)	0.823
DM	43 (39.09)	5 (35.71)	0.807
Hypertension	99 (88.39)	11 (78.57)	0.298
Hyperlipidemia	87 (79.82)	10 (71.43)	0.469
Atrial fibrillation	17 (15.04)	4 (28.57)	0.199
Current smoker	25 (22.94)	5 (35.71)	0.295
Previous MI	49 (44.14)	8 (57.14)	0.357
Previous STEMI	25 (23.58)	4 (30.77)	0.569
Previous NSTEMI	26 (24.53)	3 (23.08)	0.908
Number of former PCIs	1.04 ± 1.4	2 ± 1.6	0.014
Previous CABG	23 (20.72)	3 (21.43)	0.951
Previous restenosis	16 (14.41)	4 (28.57)	0.173
Family history of CAD	22 (22.22)	3 (23.08)	0.945
Use of statins	92 (83.64)	12 (85.71)	0.842
Use of β-blockers	88 (80.73)	10 (71.43)	0.415
Use of ACEI/ARB	91 (84.26)	9 (64.29)	0.144
Use of MRA	25 (22.94)	7 (50.00)	0.030
UA	33 (29.2)	4 (28.6)	0.837
NSTEMI	59 (53.15)	8 (57.14)	0.778
STEMI	19 (17.27)	4 (28.57)	0.306
Npl in past	13 (11.82)	2 (14.29)	0.790
History of chest radiotherapy	11 (10.28)	1 (7.14)	0.712
Cardiac arrest before PCI	7 (6.36)	1 (7.14)	0.911
LVEF (%)	47.53 ±12.0	38.93 ±15.3	0.050
TIMI grade	2.96 ±0.2	3.00 ±0.0	0.448
Hemoglobin [g/dl]	13.47 ±1.9	13.02 ±2.8	0.677
eGFR [ml/min/1.73 m^2]	67.55 ±21.4	65.69 ±22.1	0.645
Periprocedural data:			
Volume of contrast [ml]	145.9 ±54.9	156.36 ±85.5	0.850
Length of the lesion [by balloon/stent]	21.02 ±9.3	27.77 ±22.0	0.379
LM disease	1 (0.91)	2 (14.29)	0.002
DES	93 (84.55)	11 (78.57)	0.567
DEB	10 (9.01)	1 (7.14)	0.816
BMS	4 (3.6)	1 (7.14)	0.524
POBA	7 (6.36)	1 (7.14)	0.023
Diameter of the artery [mm]:			
< 1.5	4 (3.54)	1 (7.14)	0.760
1.5–2.0	2 (1.77)	0 (0)	
2.0–2.5	81 (71.68)	11 (78.57)	
> 2.5	26 (23.01)	2 (14.29)	

Table III. Cont.

Variable	No MACCE *N* = 113	MACCE *N* = 14	*P*-value
	n (%) or mean ± SD	*n* (%) or mean ± SD	
Small vessel disease (< 2.5 mm)	87 (76.99)	12 (85.71)	0.458
Coronary perforation	1 (0.90)	0 (0)	0.721
Artery occlusion	11 (9.82)	1 (7.14)	0.748
Periprocedural MI	2 (1.79)	1 (7.14)	0.215
Periprocedural complications	12 (10.62)	2 (14.29)	0.679
Follow-up:			
CCS III–IV	46 (40.71)	9 (64.29)	0.093
CCS grade	2.65 ±0.7	3.0 ±0.6	0.145
Wellbeing self-assessment [1–5]	3.5 ±1.0	3.2 ±1.1	0.416

Data are presented as number and percentage (in brackets) of patients or mean ± standard deviation. BMI – body mass index, DM – diabetes mellitus, MI – myocardial infarction, PCI – percutaneous coronary intervention, STEMI – ST-elevation myocardial infarction, NSTEMI – non-ST-elevation myocardial infarction, CABG – coronary artery bypass graft, CAD – coronary artery disease, ACEI – angiotensin-converting enzyme inhibitors, ARB – angiotensin II receptor blockers, LM – left main, MRA – mineralocorticoid receptor antagonists, SA – stable angina, UA – unstable angina, Npl – neoplasm, LVEF – left ventricular ejection fraction, TIMI – Thrombolysis In Myocardial Infarction, eGFR – estimated glomerular filtration rate, LM – left main coronary artery, D1 – first diagonal branch, D2 – second diagonal branch, LAD – left anterior descending coronary artery, Cx – circumflex coronary artery, OM1 – first obtuse marginal branch, RCA – right coronary artery, IM – intermediate artery branch, SVG – saphenous vein graft, LIMA – left internal mammary artery, DES – drug-eluting stent, DEB – drug-eluting balloon, POBA – plain old balloon angioplasty, CCS – Canadian Cardiovascular Society grading scale, MACCE – major adverse cardiovascular events.

Table IV. Univariate and logistic regression analysis of the predictors of major adverse cardiovascular events (MACCE)

Parameter	Univariate analysis			Logistic regression analysis					
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	ROC curve analysis		Hosmer–Lemeshow test
							ROC (AUC)	95% CI	*P*-value
LVEF (%)	0.95	0.92–0.99	0.0212						
Previous PCI	3.67	0.97–13.87	0.0556						
Diameter of the artery < 2.5 mm	1.79	0.38–8.53	0.4631						
LM stenting	18.17	1.53–215.51	0.0216	20.04	1.55–258.47	0.0216	0.72	0.63–0.80	1.0000
Number of former PCIs	1.48	1.05–2.09	0.0235	1.53	1.07–2.19	0.0203			

CI – confidence interval, LM – left main coronary artery, LVEF – left ventricular ejection fraction, OR – odds ratio, PCI – percutaneous coronary intervention.

tianginal pharmacotherapy constitutes the cornerstone of treatment of diffuse atherosclerosis within small coronary arteries [13, 14].

Our results are in opposition to the report by Okkonen *et al.*, as traditional risk factors were not independently associated with MACCE in our study [15]. In 3-year follow-up, Okkonen *et al.* found that major cardiovascular risk factors and Charlson comorbidity index were associated with MACCE occurrence. Our results suggest the importance of LM stenting and number of former PCI procedures as important predictors of long-term outcome after PCI.

Our findings correspond with existing data regarding MACCE risk factors. Liu *et al.* claimed that lower EF is associated with higher risk of MACCE [16]. What is interesting, in our study LM stenting and number of former PCIs were also independently associated with higher MACCE risk. Taking into consideration the clinical importance of this topic, the data on SVD revascularization outcomes and PCI-related MACCE risk factors are still scarce. Our findings may help to improve the clinical management of patients undergoing PCI.

Our study had several limitations due to its retrospective character. It covered only patients who underwent the PCI procedure between 2018 and 2020. A certain proportion of patients was lost to follow-up (45.45%). Moreover, for some patients the time of our follow-up was shorter than a year, which could limit the occurrence of MACCE and other long-term outcomes. What is also worth stressing, the definition of SVD is heterogeneous – in our study it concerned vessels ≤ 2.5 mm, but in various studies it may range from < 2 mm to < 3 mm. The

lack of difference in terms of MACCE and restenosis depending on the presence of SVD might have been due to the small study size. Moreover, the rate of restenosis was not accurately assessed as it would require scheduled coronary angiography on follow-up, which was routinely performed. However, the higher rate of refractory angina in symptomatic class III/IV among patients with SVD may be the consequence of in-stent restenosis.

Conclusions

The outcome of invasive treatment in patients with ACS is related to LM stenting and former PCIs but not to SVD occurrence. Presence of SVD does not seem to be associated with long-term MACCE occurrence in our study group. Patients with SVD have a high rate of recurrent/refractory angina despite successful PCI in this clinical setting.

Conflict of interest

The authors declare no conflict of interest.

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