Hellenic Journal of Cardiology xxx (xxxx) xxx

Contents lists available at ScienceDirect

Hellenic Journal of Cardiology

journal homepage: http://www.journals.elsevier.com/hellenic-journal-of-cardiology/

Original Article

Outcomes of patients with myocardial infarction and cardiogenic shock treated with culprit vessel-only versus multivessel primary PCI

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ARTICLE INFO

Article history:
Received 26 February 2023
Received in revised form
18 August 2023
Accepted 19 August 2023
Available online xxx

Keywords:
Acute myocardial infarction
Cardiogenic shock
Multivessel disease
Culprit vessel primary angioplasty
Multivessel primary angioplasty

ABSTRACT

Introduction and objectives: Multivessel primary percutaneous coronary intervention (pPCI) is still often used in patients with ST-elevation myocardial infarction (STEMI) and cardiogenic shock (CS). The study aimed to compare the characteristics and prognosis of patients with CS-STEMI and multivessel coronary disease (MVD) treated with culprit vessel-only pPCI or multivessel-pPCI during the initial procedure.

Material and methods: From 2016 to 2020, 23,703 primary PCI patients with STEMI were included in a national all-comers registry of cardiovascular interventions. Of them, 1,213 (5.1%) patients had CS and MVD at admission to the hospital. Initially, 921 (75.9%) patients were treated with culprit vessel (CV)-pPCI and 292 (24.1%) with multivessel (MV)-pPCI.

Results: Patients with 3-vessel disease and left main disease had a higher probability of being treated with MV-pPCI than patients with 2-vessel disease and patients without left main disease (28.5% vs. 18.6%; $p < 0.001$ and 37.7% vs. 20.6%; $p < 0.001$). Intra-aortic balloon pump, extracorporeal membrane oxygenation (ECMO), and other mechanical circulatory support systems were more often used in patients with MV-pPCI. Thirty (30)-day and 1-year all-cause mortality rates were similar in the CV-pPCI and MV-pPCI groups (odds ratio, 1.01; 95% confidence interval [CI] 0.77 to 1.32; $p = 0.937$ and 1.1; 95% CI 0.84 to 1.44; $p = 0.477$). The presence of 3-vessel disease and the use of ECMO were the strongest adjusted predictors of 30-day and 1-year mortality.

Conclusions: Our data from an extensive all-comers registry suggests that selective use of MV-pPCI does not increase the all-cause mortality rate in patients with CS-STEMI and MVD compared to CV-pPCI.

Abbreviations: pPCI, primary percutaneous coronary intervention; AMI, acute myocardial infarction; STEMI, ST-elevation myocardial infarction; CS, cardiogenic shock; MVD, multivessel coronary disease; CABG, coronary artery bypass grafting; NRCI, National Registry of Cardiovascular Interventions; CV-pPCI, culprit vessel-only primary percutaneous coronary intervention; MV-pPCI, multivessel primary percutaneous coronary intervention; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation; MCS, mechanical circulatory support.

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Peer review under responsibility of Hellenic Society of Cardiology.

https://doi.org/10.1016/j.hjc.2023.08.009

Please cite this article as: O. Hlinomaz, Z. Motovska, P. Kala *et al.*, Outcomes of patients with myocardial infarction and cardiogenic shock treated with culprit vessel-only versus multivessel primary PCI, Hellenic Journal of Cardiology, https://doi.org/10.1016/j.hjc.2023.08.009

1. Introduction

Cardiogenic shock (CS) is the leading cause of in-hospital death in patients with acute myocardial infarction (AMI)[1]. The incidence of CS complicating AMI is between 3–13%[2,3]. This means that approximately 40,000 to 50,000 CS patients are treated in the USA and approximately 60,000–70,000 in Europe per year[4]. Unfortunately, the thirty-day mortality remains high even in the primary percutaneous coronary intervention (pPCI) era at nearly 40% and approaches 50% at one year at least[5,6]. Since CABG should always be considered in patients with CS-AMI and multivessel coronary disease (MVD), the pPCI is much more often used in patients with acute myocardial infarction with ST-segment elevation (STEMI). The reason is that pPCI achieves reperfusion faster, and with improvements in PCI techniques, it can be successfully performed in most patients with MVD[7]. Data from the SHOCK trial[8,9] and an analysis of the Korean Acute Myocardial Infarction Registry[10] suggest that multivessel revascularization at the time of primary PCI was associated with better outcomes in patients with STEMI and cardiogenic shock compared with culprit vessel revascularization only. Conversely, the Culprit Lesion Only PCI Versus Multivessel PCI in Cardiogenic Shock (CULPRIT-SHOCK) trial, so far the largest randomized CS trial (published 18 years after the SHOCK trial) demonstrated that a culprit vessel-only strategy (CV-pPCI) was superior to immediate multivessel PCI (MV-pPCI) for patients with CS and multivessel coronary artery disease (MVD)[11]. This finding changed the guidelines in favor of CV-pPCI[7,12]. Nonetheless, multivessel PCI is still often used in these patients[13].

Using data from the National Registry of Cardiovascular Interventions (NRCI), National Registry of Paid Health Services, and Registry of Death Records, our study aimed to compare the characteristics and prognosis of patients with CS-STEMI and MVD treated with culprit vessel-only pPCI vs. multivessel PCI during the initial procedure.

2. Material and Methods

2.1. The National Registry of Cardiovascular Interventions (NRCI)

The NRCI is a prospective multicenter registry that collects data on all PCIs performed in all PCI centers in the Czech Republic since 2005. The NRCI is part of the National Health Information System. In recent years approx. In total, 20,000–25,000 records have been entered into the NRCI register annually. Every PCI performed in the Czech Republic, including selected clinical data, detailed data on indications for PCI, and procedural information, must be, in accordance with applicable law, consecutively entered into the NRCI. Data are subsequently correlated with the Registry of Death Records to ascertain short-term and long-term mortality[14,15]. All coronary and noncoronary interventional procedures are entered into the NRCI. Data regarding the use of the intra-aortic balloon pump (IABP), extracorporeal membrane oxygenation (ECMO), and other mechanical circulatory support systems (MCS) was obtained from the National Registry of Paid Health Services.

2.2. Patients and Definitions

Our analysis of the NRCI was performed using consecutive patients with STEMI treated with primary PCI who presented to the catheterization laboratory with cardiogenic shock or developed CS during PCI. Cardiogenic shock was diagnosed using the generally accepted definition if the patient with AMI had systolic blood pressure <90 mmHg or the use of catecholamines to maintain a systolic blood pressure of ≥90 mmHg was necessary, clinical signs of pulmonary congestion, and signs of impaired organ perfusion with at least one of the following manifestations: altered mental status, cold and clammy skin, and limbs, oliguria with a urine output of <30 ml per hour, or an arterial lactate level >2.0 mmol per liter. All patients also had to have multivessel coronary artery disease, defined as ≥70% stenosis in at least two coronary arteries. Patients with mechanical complications from AMI were excluded. All pPCI procedures were performed in high-volume PCI centers with non-stop service and at least 150 pPCI per year.

We compared baseline and procedural characteristics and 30-day and 1-year mortality among patients treated with either CV-pPCI or MV-pPCI. Culprit vessel-pPCI was defined as pPCI of only one major coronary artery or its branches, which was considered to be the cause of MI by the physician during the initial procedure. Multivessel-pPCI meant pPCI of at least two major coronary arteries or their branches during the initial procedure for STEMI with CS. The decision to perform CV-pPCI or MV-pPCI was completely up to the physician's discretion. Predictors of short- and long-term mortality were evaluated.

2.3. Statistical analysis

Continuous variables (age) were presented using arithmetic means with standard deviation (SD) for normally distributed variables. Categorical parameters were summarized using frequency tables with absolute and relative frequencies. Categorical variables were compared between treatment groups using Fisher's exact test, and continuous variables (age) were compared using the Mann-Whitney test. A p-value of <0.05 was considered statistically significant. Univariate and multivariate regression analyses were used to compare 30-day and 1-year mortality predictors. Only predictors with a p-value <0.05 in univariate entered the multivariate analysis. All analyses were performed with SPSS version 24.0.0.1 (IBM Corporation, Armonk, New York).

3. Results

3.1. Baseline patient and procedural characteristics

From January 1, 2016, to December 31, 2020, 23,703 primary PCI patients with STEMI were included in the NRCI. This period was chosen to utilize standardized registry data. A total of 1,213 (5.1%) patients had CS and MVD at admission to the hospital. Initially, 921 (75.9%) patients were treated with CV-pPCI and 292 (24.1%) with MV-pPCI. Thirty (30)-day and 1-year mortality was 50.5% vs. 51.4% and 59.0% vs. 61.3% in CV-pPCI and MV-pPCI groups. In total, 64 (21.9%) patients in MV-pPCI had 100% stenoses in two vessels.

Table 1 shows the baseline clinical characteristics of patients with CS-STEMI and MVD treated either with CV-pPCI or MV-pPCI. CV-pPCI was preferred over MV-pPCI in all patients, both men and women, although women were more often treated with CV-pPCI than men (79.8% vs. 74.6%; $p < 0.001$). Culprit vessel-pPCI and MV-pPCI patients did not differ regarding age, previous PCI and CABG, chronic kidney disease, cardiopulmonary resuscitation, and artificial lung ventilation at admission.

Culprit vessel-pPCI, compared to MV-pPCI patients, had the same occurrence of anterior myocardial infarction, time delay to reperfusion, and thrombolysis in myocardial infarction (TIMI) flow 0 before PCI (Table 2). Patients with MV-pPCI were significantly more likely to have 3-vessel or left main disease. Post-procedural TIMI flow 3 in the culprit artery was achieved more often in patients with CV-pPCI (76.8% vs. 66.8%; $p < 0.001$). Intra-aortic balloon pump, ECMO, and other MCS were more often used in patients with MV-pPCI.

Table 1
Characteristics of the patients at baseline.

	All patients N (total %)	CV-pPCI	MV-pPCI	p
		N (%)	N (%)	
Total	1213 (100)	921 (75.9)	292 (24.1)	-
Male	896 (73.9)	668 (74.6)	228 (25.4)	< **0.001**
Age years (mean ± SD)	68 ± 11.4	68.1 ± 11.2	66.2 ± 11.4	0.780
<40	10 (0.8)	7 (70.0)	3 (30.0)	0.125
40–49	62 (5.1)	39 (62.9)	23 (37.1)	
50–59	196 (16.2)	144 (73.5)	52 (26.5)	
60–69	405 (33.4)	313 (77.3)	92 (22.7)	
70–79	342 (28.2)	260 (76.0)	82 (24.0)	
≥80	198 (16.3)	158 (79.8)	40 (20.2)	
Previous PCI	183 (15.1)	148 (80.9)	35 (19.1)	0.890
Previous CABG	71 (5.9)	57 (80.3)	14 (19.7)	0.376
Chronic kidney disease/failure	87 (7.2)	63 (72.4)	24 (27.6)	0.426
After CPR	728 (60.0)	556 (76.4)	172 (23.6)	0.657
Artificial lung ventilation	821 (67.7)	615 (74.9)	206 (25.1)	0.227

PCI, percutaneous coronary intervention; CV-pPCI, culprit vessel only primary PCI; MV-pPCI, multivessel primary PCI; N, number; SD, standard deviation; CABG, coronary artery bypass grafting; CPR, cardiopulmonary resuscitation; Mann-Whitney test with p-value was used for continuous variables (age). Categorical parameters (others) are expressed as absolute numbers (percentages) and compared using Fisher's exact test.

3.2. Predictors of 30-day and 1-year all-cause mortality

Based on the results of univariate logistic regression analysis, 30-day, and 1-year all-cause mortality was similar in the CV-pPCI and MV-pPCI groups (odds ratio [OR], 1.01; 95% confidence interval [CI] 0.77 to 1.32; p = 0.937 and 1.1; 0.84 to 1.44; p = 0.477, respectively). The predictors of 30-day and 1-year mortality among all patients with CS-STEMI and MVD were age above 70 years (OR, 1.48; 95% CI 1.1 to 1.99; p = 0.009 and 1.6; 1.18 to 2.16; p = 0.002), presence of chronic kidney disease or failure (1.58; 1.01 to 2.49; p = 0.047 and 1.86; 1.15 to 3.02; p = 0.012), artificial lung ventilation (1.34; 1.05 to 10.71; p = 0.019 and 1.3; 1.02 to 1.66; p = 0.036), 3-vessel disease (1.59; 1.26 to 2.00; p < 0.001 and 1.64; 1.30 to 2.06; p < 0.001), left main disease (1.4; 1.05 to 1.88; p = 0.022 and 1.5; 1.11 to 2.02; p = 0.008) and use of extracorporeal membrane oxygenation (ECMO) on the same day as pPCI (1.74; 1.07 to 2.82; p = 0.024 and 1.64; 1.00 to 2.68; p = 0.050). Post-procedural TIMI flow 3 (0.36; 0.23 to 0.56, p < 0.001 and 0.54; 0.35 to 0.82, p = 0.004) and inferior or posterior MI localization (0.63; 0.49 to 0.82; p < 0.001 and 0.61; 0.47 to 0.78; p < 0.001) increased the probability of survival (Fig. 1). Using multivariate logistic regression analysis, the presence of 3-vessel disease was a strong independent predictor of 30-day and 1-year mortality in patients with CS-STEMI and MVD treated with pPCI (OR 1.60; 95% CI 1.27 to 2.03; p < 0.001 and 1.64; 1.30 to 2.07; p < 0.001, respectively). The other strong independent predictor of 30-day and 1-year mortality was the use of ECMO on the same day as pPCI (OR 1.83; 95% CI 1.12 to 2.98; p = 0.016 and 1.70; 95% CI 1.03 to 2.81; p = 0.037) (Table 3).

4. Discussion

Using data from the all-comers national registries, this study evaluated the characteristics and prognosis of patients with STEMI, CS, and MVD treated with culprit vessel-only pPCI or multivessel PCI during the initial procedure. We suggest that the selective use of MV-pPCI does not increase the mortality rate in patients with CS-STEMI and MVD compared to CV-pPCI.

The treatment for patients with STEMI and MVD is under continuous debate and is very different depending on whether the patient is in CS. Studies published in the previous decade in patients with STEMI and MVD without CS proved that complete revascularization of all significant coronary lesions improves the prognosis of the patients[16-23]. Current European Society of Cardiology (ESC), American College of Cardiology (ACC), and Japanese guidelines, recommend PCI on culprit lesions during the initial procedure and PCI or CABG for non-culprit stenoses using a staged procedure during hospitalization or within 40 days of the index myocardial infarction[7,12,24,25]. Performing PCI on all significant stenoses during the initial procedure can be done on stable patients with non-complex lesions suitable for uncomplicated, low-risk PCI[12,16]. The question remains, how to recognize non-culprit lesions that may cause major adverse cardiac events in the future. Some authors recommend using the angiographic severity of the stenosis as an indicator (≥70% diameter stenosis). Others emphasize the role of functional hemodynamic testing (fractional flow reserve and similar methods), intravascular imaging (optical coherence tomography, intravascular ultrasound, near-infrared spectroscopy), positron emission tomography, nuclear magnetic resonance, computer tomography or non-invasive testing like single photon computer tomography, or exercise echocardiography[26-33]. Effective pharmacotherapeutic stabilization and even regression of atherosclerotic plaques must also be considered[34-36]. The situation for patients with STEMI and cardiogenic shock is different from those who are hemodynamically stable. On the one hand, treatment of all ischemic lesions during initial primary PCI may improve perfusion of the myocardium, thus increasing heart contractility; on the other hand, any possible complication, including the relatively frequent troponin elevations that occurs during non-culprit PCI can lead to critical clinical consequences and progression of shock. Multivessel PCI also prolongs procedural times and can lead to contrast-induced nephropathy. Significant vasoconstriction often occurs in STEMI, especially in CS patients, where catecholamines are frequently used. This can lead to overestimation of coronary stenoses and their treatment by inappropriate PCI[24,37,38]. These are the probable explanations for the results seen in the CULPRIT-SHOCK trial, in which patients with STEMI or non-STEMI (NSTEMI) with cardiogenic shock were randomized to culprit lesion-only PCI or immediate PCI of all obstructive lesions (i.e., those with >70% stenosis of the diameter)[11]. In the multivessel PCI group, recanalization of chronic total occlusions was performed when possible, and complete revascularization was achieved in 81% of patients. In the culprit lesion-only PCI group, staged revascularization was performed in 17.7% of the patients. At 30 days, the primary endpoint (i.e., death or severe renal failure leading to renal replacement therapy) was higher with immediate multivessel PCI than with culprit lesion-only PCI. The results were similar for death from any cause and were consistent across the pre-specified subgroups. At one year, the mortality did not differ significantly between the two

Table 2
Procedural characteristics.

	All patients N (total %)	CV-pPCI N (%)	MV-pPCI N (%)	p
MI location				
Anterior	640 (52.8)	468 (73.1)	172 (26.9)	0.671
Inferior/posterior	401 (33.1)	335 (83.5)	66 (16.5)	
Lateral	95 (7.8)	65 (68.4)	30 (31.6)	
Not known/LBBB	77 (6.3)	53 (68.8)	24 (31.2)	-
Time from symptom onset to PCI				
<2 hr (<120 min)	62 (5.1)	48 (77.4)	14 (22.6)	0.722
2–3 hr (120–179 min)	21 (1.7)	15 (71.4)	6 (28.6)	
3–4 hr (180–239 min)	19 (1.6)	13 (68.4)	6 (31.6)	
4–8 hr (240–479 min)	118 (9.7)	95 (80.5)	23 (19.5)	
>8 hr (≥480 min)	949 (78.2)	725 (76.4)	224 (23.6)	
Not known	44 (3.6)	25 (56.8)	19 (43.2)	-
No. of diseased vessels *				
1	0 (0.0)	0 (0.0)	0 (0.0)	-
2	547 (45.1)	445 (81.4)	102 (18.6)	**<0.001**
3	666 (54.9)	476 (71.5)	190 (28.5)	
Left main stenosis >50%	239 (19.7)	149 (62.3)	90 (37.7)	**<0.001**
TIMI flow before PCI				
0	768 (63.3)	581 (75.7)	187 (24.3)	0.675
1	131 (10.8)	96 (73.3)	35 (26.7)	
2	168 (13.8)	128 (76.2)	40 (23.8)	
3	146 (12.0)	116 (79.5)	30 (20.5)	
TIMI flow after PCI				
0	110 (9.1)	63 (57.3)	47 (42.7)	**< 0.001**
1	56 (4.6)	41 (73.2)	15 (26.8)	
2	145 (12.0)	110 (75.9)	35 (24.1)	
3	902 (74.4)	707 (78.4)	195 (21.6)	
Procedures				
IABP the same day as PCI	78 (6.4%)	47 (5.1%)	31 (10.6%)	**0.001**
ECMO on the same day as PCI	80 (6.6%)	49 (5.3%)	31 (10.6%)	**0.003**
MCS - short/medium term the same day as PCI	11 (0.9%)	5 (0.5%)	6 (2.1%)	**0.028**
MCS - long-term the same day as PCI	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
IABP from 1-30 days after PCI	9 (0.7%)	6 (0.7%)	3 (1.0%)	0.456
ECMO from 1-30 days after PCI	15 (1.2%)	8 (0.9%)	7 (2.4%)	0.062
MCS - short/medium term from 1-30 days after PCI	4 (0.3%)	1 (0.1%)	3 (1.0%)	**0.045**
MCS - long-term from 1-30 days after PCI	3 (0.2%)	1 (0.1%)	2 (0.7%)	0.146
Complications				
Vessel complications requiring surgery	5 (0.4)	2 (0.2)	3 (1.0)	0.094
Severe bleeding	3 (0.2)	2 (0.2)	1 (0.3)	0.563
Part of the year				
Spring	316 (26.1)	245 (77.5)	71 (22.5)	0.790
Summer	299 (24.6)	231 (77.3)	68 (22.7)	
Autumn	293 (24.2)	206 (70.3)	87 (29.7)	
Winter	305 (25.1)	239 (78.4)	66 (21.6)	
Part of the day (in time of PCI)				
8:00-16:00 (working hours)	74 (6.1)	55 (74.3)	19 (25.7)	0.957
16:00-8:00 (not working hours)	83 (6.8)	62 (74.7)	21 (25.3)	
Not known	1056 (87.1)	804 (76.1)	252 (23.9)	-
Day in the week (in time of PCI)				
Monday	161 (13.3)	116 (72)	45 (28)	0.864
Tuesday	195 (16.1)	150 (76.9)	45 (23.1)	
Wednesday	151 (12.4)	119 (78.8)	32 (21.2)	
Thursday	174 (14.3)	133 (76.4)	41 (23.6)	
Friday	192 (15.8)	148 (77.1)	44 (22.9)	
Saturday	173 (14.3)	131 (75.7)	42 (24.3)	
Sunday	167 (13.8)	124 (74.3)	43 (25.7)	

PCI, percutaneous coronary intervention; CV-pPCI, culprit vessel only primary PCI; MV-pPCI, multivessel primary PCI; MI, myocardial infarction; TIMI, Thrombolysis in Myocardial Infarction; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation; MCS, mechanical circulatory support.
Categorical parameters are expressed as absolute numbers (percentage) and compared using Fisher's exact test. * Definition variable.

groups[39]. The CULPRIT-SHOCK trial provided clear evidence that a culprit lesion-only PCI strategy is preferred over initial multivessel PCI for patients with cardiogenic shock[11]. Multivessel PCI should not be performed on a routine basis but can be considered in some patients[7,12,24,37,40].

Using data from a national all-comers registry, we tried to analyze the differences between CV-pPCI and MV-pPCI during the initial intervention in patients with CS-STEMI. The incidence of CS and MVD among patients with STEMI treated with pPCI was 5.1% in our registry, which is similar to other data sources[40,41]. Since the analysis included the years 2016–2020, the interventional treatment of CS-STEMI was mostly influenced by the ESC STEMI guidelines published in 2017 and by ESC Revascularization guidelines published in 2018[7,42]. The ESC STEMI guidelines state that immediate PCI is indicated for patients with cardiogenic shock if coronary anatomy is suitable (class I) and complete revascularization during the index procedure should be considered (class IIa). However, after the results of CULPRIT-SHOCK were published, the ESC Revascularization guidelines postulated that in cardiogenic shock, routine revascularization of

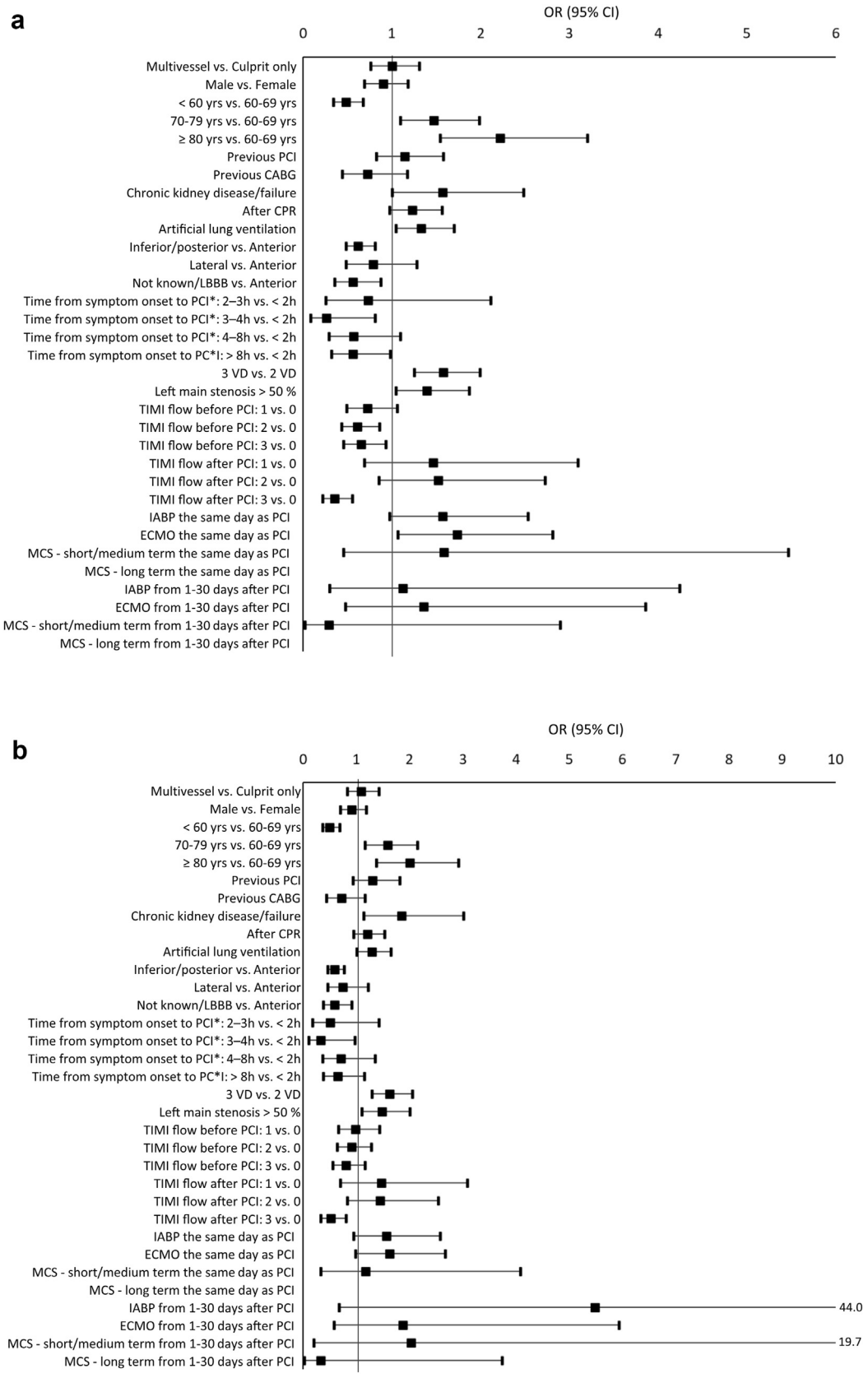

Figure 1. a Predictors of 30-day all-cause mortality. Calculated by univariate logistic regression analysis. OR, odds ratio; CI, confidence interval; yrs., years; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; CPR, cardiopulmonary resuscitation; MI, myocardial infarction; LBBB, left bundle branch block; TIMI, Thrombolysis in Myocardial Infarction; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation; MCS, mechanical circulatory support. b Predictors of 1-year all-cause mortality. Calculated by univariate logistic regression analysis. OR, odds ratio; CI, confidence interval; yrs., years; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; CPR, cardiopulmonary resuscitation; MI, myocardial infarction; LBBB, left bundle branch block; TIMI, Thrombolysis in Myocardial Infarction; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation; MCS, mechanical circulatory support.

Table 3
Predictors of 30-day and 1-year all-cause mortality (multivariate logistic regression analysis).

Predictor	30-days mortality		1-year mortality	
	OR (95% IS)	p	OR (95% IS)	p
Primary PCI	0.90 (0.68; 1.18)	0.439	0.99 (0.75; 1.30)	0.923
Gender	1.16 (0.89; 1.51)	0.273	1.15 (0.88; 1.51)	0.292
3VD vs. 2VD	1.60 (1.27; 2.03)	**<0.001**	1.64 (1.30; 2.07)	**<0.001**
Left main stenosis > 50%	1.01 (1.00; 1.03)	0.139	1.02 (1.00; 1.04)	0.101
IABP the same day as PCI	1.48 (0.91; 2.40)	0.110	1.45 (0.88; 2.40)	0.147
ECMO on the same day as PCI	1.83 (1.12; 2.98)	**0.016**	1.70 (1.03; 2.81)	**0.037**

PCI, percutaneous coronary intervention; 3VD, 3-vessel disease; 2VD, 2-vessel disease; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation. Values OR > 1 mean category of the predictor, which is concerning mortality riskier than reference category. Values OR < 1 mean category, and compared with the reference category was less risky. P-values <0.05 are statistically significant; confidence interval does not include the value of 1.

non−infarct-related artery (non-IRA) lesions is not recommended during primary PCI (class III). Some specific angiographic scenarios, such as subtotal non-culprit lesions with reduced TIMI flow or multiple possible culprit lesions, may benefit from immediate multivessel PCI. However, this should be considered on an individual basis[40]. We were surprised that, despite these recommendations, the percentage of MV-pPCI in the Czech all-comers registry had risen from 19.17% in 2016 to 30.74% in 2020. This trend will need further evaluation and discussion within the national interventional community. Data from the Polish Registry Of Acute Coronary Syndromes (PL-ACS) of patients with AMI complicated with CS and treated with PCI between 2008 and 2019 showed more frequent use of MV-pPCI than CV-pPCI (54.2% vs. 45.8%)[13]. CV-pPCI and MV-pPCI patients did not differ in most baseline clinical and procedural characteristics. Patients with MV-pPCI were likelier to have significant 3-vessel or left main disease. TIMI flow 3 in the culprit artery was achieved more often in patients undergoing CV-pPCI than MV-PCI, which was contrary to PL-ACS data. We presume that in routine clinical practice, physicians finish the procedure if TIMI flow 3 is achieved in the culprit lesion; if not, they try to treat the other coronary vessels. Thrombolysis in MI flow 3 after pPCI was achieved in 74.4% of our study population, which is similar to the Polish registry and lower than in the CULPRIT-SHOCK trial[11,13]. The difference can be explained by the selection of patients in the randomized trial. Intra-aortic balloon pump, ECMO, and other MCS were only used in 16.3% of our patients, which is comparable to the PL-ACS registry but less often than in the CULPRIT-SHOCK trial[11,13]. IABP, ECMO, and other MCS were more often used in patients with MV-pPCI. Bleeding was rarely reported in NRCI, and we consider these data underestimated and irrelevant. Different seasons of the year, day of the week, or pPCI performed during working or non-working hours did not affect the choice of interventional strategy (Table 2); the same was true in the subanalysis of the CULPRIT-SHOCK trial[43].

Thirty-day and 1-year mortality were 50.5% vs. 51.4% and 59.0% vs. 61.3% in CV-pPCI and MV-pPCI groups in our all-comers registry. This is consistent with data from other trials and registries[11,13,38,40,44-48]. The mortality was similar in the CV-pPCI and MV-pPCI groups (odds ratio, 0.99; 95% CI 0.76 to 1.29; p = 0.937 and 0.91; 0.69 to 1.19; p = 0.477, respectively). As we do not have sufficient data about the severity of CS in both groups and IABP, ECMO, and other MCS were more often used in patients with MV-pPCI, the mortality may also be affected. On the other hand, we currently do not have any data demonstrating the role of IABP, ECMO, or other MCS on the overall mortality of patients with AMI and CS.[49] Using univariate logistic regression analyses, the positive predictors of mortality among all patients with CS-STEMI and MVD were age above 70 years, chronic kidney disease or failure, mechanical ventilation, 3-vessel, left main disease, and use of ECMO. Thrombolysis in MI flow 3 at the end of pPCI, as well as an inferior or posterior myocardial infarction increased the probability of survival. Other risk factors for adverse prognosis such as biomarkers (glucose, creatinine, cystatin C, lactate, interleukin-6, brain natriuretic peptide) and markers of hemodynamic instability (pulmonary capillary wedge pressure, left ventricular end-diastolic pressure) were not followed in the registry[40,50-52]. The IABP-SHOCK II risk score, which is the only CS risk score with both internal and external validation, could not be calculated from registry data[53]. Based on a multivariate logistic regression analysis, the presence of 3-vessel disease and the use of ECMO were the strongest adjusted predictors of 30-day and 1-year all-cause mortality in our patients.

5. Study Limitations

Our study analyzed all-comers registries, and these types of studies always have limitations. On the other side, the registry was unique, complex, consistent with applicable law (i.e., all patient data are required to be entered into the registry), and involved consecutively treated patients. Some data regarding prognostic risk factors in patients with CS, such as biomarkers or markers of hemodynamic instability, were not followed in our registry. Likewise, we did not have data on the severity of CS, use of catecholamines, and prevalence of bleeding. The higher use of IABP, ECMO, and other MCS in the MV-pPCI group may have influenced the study results.

6. Conclusions

Our data from a large all-comers registry suggests that selective use of MV-pPCI does not increase the mortality rate in patients with CS-STEMI and MVD compared to CV-pPCI.

Funding

The work was supported by the Ministry of Health of the Czech Republic, Grant No. NV19-02-00086. All rights reserved. The work was further supported by the Charles University, Czech Republic, Research Program COOPERATIO—Cardiovascular Science and by the project National Institute for Research of Metabolic and Cardiovascular Diseases (Program EXCELES, ID Project No. LX22NPO5104) - Funded by the European Union—Next Generation EU.

Conflict of interest

The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

Author contributions

O. Hlinomaz contributed to writing - original draft preparation, writing - reviewing and editing, and visualization. Z. Motovska contributed to conceptualization, methodology, writing - reviewing and editing, and supervision. P. Kala, M. Hromadka, J. Precek, J. Mrozek, P. Cervinka, J. Kettner, J. Matejka, A. Zohor, J. Bis contributed to data curation. J. Jarkovsky contributed to formal analysis and data curation. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki.

Informed Consent Statement

Informed consent for performing PCI was obtained. Data from patients treated with PCI must be, in accordance with applicable law, entered into the national registry.

Impact on Daily Practice

Selective use of multivessel primary PCI does not increase the 30-day and 1-year mortality in patients with STEMI, CS, and MVD compared to CV-pPCI. The predictors of mortality were age above 70 years, presence of chronic kidney disease or failure, artificial lung ventilation, 3-vessel, left main disease, and use of ECMO. TIMI flow 3 at the end of primary PCI and inferior myocardial infarction increased the probability of survival.

Acknowledgments

The authors thank all Czech interventional cardiologists from 23 cardiovascular centers for entering data into the NRCI registry (Supplement 1). Thanks also to Mr. Thomas Secrest (Secrest Editing, Inc.) for English editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.hjc.2023.08.009.

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