Temporal trends in in-hospital mortality of 7628 patients with myocardial infarction complicated by cardiogenic shock treated in the years 2006–2021. An analysis from the SILCARD Database

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INTRODUCTION

Cardiogenic shock (CS) is a low-cardiac-output state characterized by life-threatening end-organ hypoperfusion and hypoxia. Myocardial infarction (MI) with left ventricular failure remains one of the most frequent causes of CS [1]. The widespread implementation of early revascularization has decreased mortality from the previous 70%–80% to 40%–50% [2, 3]. Despite significant advances in percutaneous coronary interventions (PCI) and mechanical circulatory support (MCS) techniques, outcomes for patients with MI complicated by CS (MI-CS) remain unsatisfactory. Although some data suggest that treatment outcomes in this population have improved in recent years [4, 5], many authors highlight that in-hospital mortality of CS complicating MI has remained unchanged [2, 3]. Moreover, some recent registries have even shown an increase in mortality rates, which may be a consequence of the aging patient population and increasing risk profiles of CS patients [6, 7]. There is a paucity of comprehensive data concerning changes in treatment strategies and outcomes for all-comer MI-CS patients in recent years.

Therefore, we aimed to analyze the recent trends in the mortality of patients hospitalized with a diagnosis of MI-CS, as recorded in the Silesian Cardiovascular Database (SILCARD).

MATERIAL AND METHODS

General information in the SILCARD database (ClinicalTrials.gov identifier, NCT02743533) was described previously [8]. In brief, the SIL-

CARD database was created under an agreement between the Silesian Center for Heart Diseases in Zabrze and the Silesian branch of the National Health Fund (NHF), the only health provider in Poland supplying data from patients with cardiovascular diseases. It contains records from all hospitals (n = 310) in the Silesian Province, a highly industrialized administrative region in Poland with a population of 4.4 million (11.6% of Poland's total population).

The Silesian Province provides a well-developed hospital network with two tertiary cardiology hospitals, three cardiac surgery departments, and 20 catheterization laboratories. The NHF supplied the database with all data from 2006. The inclusion criteria were as follows: each hospitalization in the departments of cardiology, cardiac surgery, vascular surgery, or diabetology, and hospitalization with a cardiovascular diagnosis in the department of intensive care or internal medicine. The exclusion criteria were hospitalization of patients younger than 18 years on admission or patients living outside of the Silesian Province.

The analysis included all patients from the SILCARD database hospitalized between 2006 and 2021with a principal diagnosis of CS (R57.0 code according to the International Classification of Diseases, 10th Revision [ICD-10] and MI diagnosis [I21–I22 code according to ICD-10]). Medical procedures were defined by the ICD-9 classification. The disease diagnoses involved in the table were based on data submitted to the NHF. It should be assumed that heart failure included patients diagnosed both before and during hospitalization, without differentiation into reduced, mildly reduced, or preserved ejection fraction types.

The clinical characteristics, management, in-hospital, and one-year mortality were analyzed as trends across the years. Both all-cause mortality data and medical procedures during 1-year follow-up were obtained from the NHF records. Vital status at 12 months after MI-CS was available for all patients.

Statistical analysis

Continuous variables were presented as means with standard deviations or medians with interquartile ranges, and categorical variables as counts and percentages. The significance of the time trends in the studied years was calculated using ANOVA with linear trend contrasts set for age, the Jonckheere–Terpstra trend test for in-hospital stay, and the Cochran–Armitage test for categorical variables. The significance of the difference between the two groups was assessed using the t-test or the χ^2 test, depending on the type of data. TIBCO Software Inc. (2017) Statistica (data analysis software system), version 13.3, was used for all calculations.

RESULTS AND DISCUSSION

The analysis involved 7628 residents of the Silesian Province hospitalized with a diagnosis of CS from January 1, 2006, to December 31, 2021. Trends in patient characteristics, in-hospital, and 12-month outcomes are presented in Table 1. There was a significant decrease in the percentage of patients with CS complicating ST-segment elevation MI (P <0.001) and the use of MCS with intra-aortic balloon pump (P <0.001) over the years 2006–2021. Despite an increase in the frequency of coronary angiography and percutaneous revascularization procedures, there were no significant changes in in-hospital and 1-year mortality trends. At the same time, there were increasing trends in the occurrence of hypertension and diabetes, as well as in the presence of co-existing comorbidities and previous revascularization procedures. Although a significant increasing trend was found in the percentage of patients undergoing rehabilitation after MI-CS (P <0.001), the rate remained relatively low.

Our analysis found no significant changes in in-hospital mortality trends in MI-CS patients treated in the Silesian Province from 2006 to 2021. Although such results may seem disappointing, it is necessary to emphasize the increasing trends in the incidence of co-existing comorbidities in MI-CS patients, including heart failure, diabetes, previous MIs, strokes, and renal failure. Theoretically, these factors should lead to an increased mortality rate in the analyzed period. The growing availability of PCI procedures and advancements in CS treatment may have prevented an increase in the mortality rate.

There are few data assessing trends in in-hospital mortality in the population of CS patients in recent years [4, 5]. Osman et al. [4] showed a reduction in in-hospital mortality in American MI-CS patients from 44% in 2004 to 35% in 2018 (P trend <0.001). In the analysis of 441 696 patients with CS treated in Germany between 2005 and 2017, the in-hospital mortality rate remained around 60%. There was a trend towards lower mortality in patients with MI-CS, without clear improvements in patients without MI [5]. Generally, the unsatisfactory outcomes of MI-CS treatment have not substantially changed in the past 25 years [1–3, 6, 9, 10].

The only available method of treatment in this group of patients with confirmed clinical efficacy is early revascularization [9]. We found an increase in the frequency of PCI procedures with a much lower and stable percentage of patients undergoing coronary artery bypass grafting. This may be surprising if we assume that a certain proportion of patients may have had multivessel coronary artery disease. In another study from the SILCARD database, MI-CS patients undergoing coronary artery bypass grafting had lower in-hospital mortality than those undergoing PCI [11]. In our analysis, the use of intra-aortic balloon pumps decreased significantly over the years, and the use of extracorporeal membrane oxygenation remained marginal. In the mentioned earlier German analysis, the more frequent use of extracorporeal membrane oxygenation and other percutaneous MCS techniques did not significantly improve treatment results [5].

The treatment of patients with MI complicated by CS remains a problem requiring not only therapeutic but also

Table 1. Trends in patients characteristics, in-hospital and 12 months outcomes

Patients characteristics	Total n = 7628	2006 n = 523	2007 n = 466	2008 n = 422	2009 n = 432	2010 n = 455	2011 n = 523	2012 n = 549	2013 n = 499	2014 n = 493	2015 n = 469	2016 n = 446	2017 n = 511	2018 n = 494	2019 n = 477	2020 n = 456	2021 n = 413	Trend tests, *P*-value
Age, years, mean (SD)	70.2 (11.3)	69.0 (11.5)	69.4 (11.8)	70.0 (12.4)	69.1 (11.3)	69.3 (11.3)	69.9 (11.5)	70.3 (11.6)	69.9 (10.8)	69.8 (11.7)	70.5 (11.3)	70.7 (11.3)	71.3 (10.4)	71.1 (10.6)	71.0 (11.3)	70.5 (11.0)	70.5 (11.3)	<0.001
In-hospital stay, days, median (IQR)	4 (2–9)	3 (2–8)	3 (1–9)	4 (2–8)	4 (2–10)	5 (2–10)	5 (2–9)	4 (2–9)	4 (2–10)	4 (1–9)	4 (1–9)	4 (2–10)	5 (2–10)	5 (2–11)	5 (2–11)	5 (2–11)	4 (1–10)	<0.001
Female sex, n (%)	3192 (41.8)	232 (44.4)	209 (44.8)	192 (45.5)	180 (41.7)	192 (42.2)	218 (41.7)	228 (41.5)	206 (41.3)	191 (38.7)	196 (41.8)	178 (39.9)	221 (43.2)	194 (39.3)	195 (40.9)	182 (39.9)	178 (43.1)	0.028
STEMI, n (%)	4976 (65.2)	385 (73.6)	340 (73.0)	311 (73.7)	314 (72.7)	309 (67.9)	352 (67.3)	346 (63.0)	300 (60.1)	323 (65.5)	280 (59.7)	276 (61.9)	308 (60.3)	301 (60.9)	279 (58.5)	278 (61.0)	274 (66.3)	<0.001
NSTEMI, n (%)	2485 (32.6)	98 (18.7)	102 (21.9)	105 (24.9)	110 (25.5)	133 (29.2)	160 (30.6)	189 (34.4)	192 (38.5)	166 (33.7)	182 (38.8)	163 (36.5)	194 (38.0)	184 (37.2)	197 (41.3)	177 (38.8)	133 (32.2)	<0.001
Non-identified MI, n (%)	167 (2.2)	40 (7.6)	24 (5.2)	6 (1.4)	8 (1.9)	13 (2.9)	11 (2.1)	14 (2.6)	7 (1.4)	4 (0.8)	7 (1.5)	7 (1.6)	9 (1.8)	9 (1.8)	1 (0.2)	1 (0.2)	6 (1.5)	0.003
Hypertension, n (%)	5442 (71.3)	172 (32.9)	247 (53.0)	250 (59.2)	277 (64.1)	323 (71.0)	394 (75.3)	412 (75.0)	363 (72.7)	379 (76.9)	367 (78.3)	354 (79.4)	405 (79.3)	387 (78.3)	393 (82.4)	375 (82.2)	344 (83.3)	<0.001
Diabetes, n (%)	2667 (35.0)	95 (18.2)	119 (25.5)	126 (29.9)	129 (29.9)	131 (28.8)	183 (35.0)	200 (36.4)	183 (36.7)	172 (34.9)	173 (36.9)	183 (41.0)	204 (39.9)	203 (41.1)	196 (41.1)	213 (46.7)	157 (38.0)	<0.001
Atrial fibrillation, n (%)	826 (10.8)	15 (2.9)	35 (7.5)	22 (5.2)	31 (7.2)	38 (8.4)	61 (11.7)	68 (12.4)	53 (10.6)	47 (9.5)	57 (12.2)	64 (14.3)	62 (12.1)	64 (13.0)	71 (14.9)	72 (15.8)	66 (16.0)	<0.001
Heart failure, n (%)	518 (33.0)	108 (20.7)	111 (23.8)	116 (27.5)	127 (29.4)	151 (33.2)	174 (33.3)	193 (35.2)	179 (35.9)	181 (36.7)	147 (31.3)	161 (36.1)	189 (37.0)	164 (33.2)	186 (39.0)	179 (39.3)	152 (36.8)	<0.001
Renal failure, n (%)	592 (7.8)	9 (1.7)	11 (2.4)	20 (4.7)	28 (6.5)	29 (6.4)	37 (7.1)	34 (6.2)	43 (8.6)	34 (6.9)	43 (9.2)	44 (9.9)	54 (10.6)	53 (10.7)	60 (12.6)	53 (11.6)	40 (9.7)	<0.001
PVD, n (%)	3237 (42.8)	106 (20.3)	151 (32.4)	134 (31.8)	168 (38.9)	175 (38.5)	223 (42.6)	241 (43.9)	217 (43.5)	217 (44.0)	239 (51.0)	212 (47.5)	247 (48.3)	229 (46.4)	233 (48.8)	241 (52.9)	204 (49.4)	<0.001
Previous MI, n (%)	1114 (14.6)	27 (5.2)	39 (8.4)	35 (8.3)	57 (13.2)	58 (12.7)	76 (14.5)	99 (18.0)	74 (14.8)	77 (15.6)	74 (15.8)	74 (16.6)	86 (16.8)	84 (17.0)	91 (19.1)	83 (18.2)	80 (19.4)	<0.001
Previous PCI, n (%)	1161 (15.2)	13 (2.5)	18 (3.9)	27 (6.4)	46 (10.6)	68 (14.9)	64 (12.2)	86 (15.7)	79 (15.8)	74 (15.0)	81 (17.3)	84 (18.8)	107 (20.9)	110 (22.3)	111 (23.3)	99 (21.7)	94 (22.8)	<0.001
Previous CABG, n (%)	166 (2.2)	0 (0.0)	1 (0.2)	2 (0.5)	4 (0.9)	5 (1.1)	6 (1.1)	10 (1.8)	10 (2.0)	13 (2.6)	21 (4.5)	14 (3.1)	9 (1.8)	16 (3.2)	18 (3.8)	20 (4.4)	17 (4.1)	<0.001
Previous stroke, n (%)	455 (6.0)	5 (1.0)	12 (2.6)	18 (4.3)	8 (1.9)	23 (5.1)	25 (4.8)	30 (5.5)	31 (6.2)	40 (8.1)	43 (9.2)	28 (6.3)	46 (9.0)	31 (6.3)	34 (7.1)	45 (9.9)	36 (8.7)	<0.001
In-hospital outcomes																		
Coronary angiography, n (%)	6179 (81.0)	287 (54.9)	269 (57,7)	251 (59.5)	329 (76.2)	347 (76.3)	438 (83.7)	465 (84.7)	437 (87.6)	420 (85.2)	399 (85.1)	397 (89.0)	453 (88.6)	441 (89.3)	444 (93.1)	418 (91.7)	384 (93.0)	<0.001
PCI, n (%)	5409 (70.9)	225 (43.0)	208 (44.6)	215 (50.9)	290 (67.1)	293 (64.4)	390 (74.6)	419 (76.3)	368 (73.7)	374 (75.9)	364 (77.6)	352 (78.9)	393 (76.9)	387 (78.3)	396 (83.0)	385 (84.4)	350 (84.7)	<0.001
CABG, n (%)	199 (2.6)	9 (1.7)	6 (1.3)	12 (2.8)	8 (1.9)	13 (2.9)	17 (3.3)	18 (3.3)	11 (2.2)	13 (2.6)	7 (1.5)	16 (3.6)	14 (2.7)	17 (3.4)	15 (3.1)	16 (3.5)	7 (1.7)	0.05
IABP, n (%)	1835 (24.1)	115 (22.0)	101 (21.7)	104 (24.6)	110 (25.5)	146 (32.1)	185 (35.4)	177 (32.2)	121 (24.2)	120 (24.3)	83 (17.7)	103 (23.1)	107 (20.9)	96 (19.4)	93 (19.5)	100 (21.9)	74 (17.9)	<0.001
ECMO, n (%)	38 (0.5)	0 (0.0)	0 (0.0)	2 (0.5)	0 (0.0)	1 (0.2)	1 (0.2)	1 (0.2)	1 (0.2)	1 (0.2)	3 (0.6)	8 (1.8)	0 (0.0)	2 (0.4)	9 (1.9)	8 (1.8)	1 (0.2)	<0.001
Respiratory therapy, n (%)	4235 (55.5)	326 (62.3)	308 (66.1)	223 (52.8)	194 (44.9)	259 (56.9)	295 (56.4)	300 (54.6)	289 (57.9)	302 (61.3)	275 (58.6)	272 (61.0)	271 (53.2)	245 (49.6)	241 (50.5)	239 (52.4)	195 (47.2)	<0.001
In-hospital mortality, n (%)	4955 (65.0)	342 (65.4)	328 (70.4)	283 (67.1)	261 (60.4)	297 (65.3)	330 (63.1)	344 (62.7)	308 (61.7)	323 (65.5)	297 (63.3)	312 (70.0)	338 (66.1)	315 (63.8)	309 (64.8)	298 (65.4)	270 (65.4)	0.43
Outcomes at 12 months																		
Rehabilitation, n (%)	929 (12.2)	56 (10.7)	48 (10.3)	45 (10.7)	44 (10.2)	40 (8.8)	58 (11.1)	61 (11.1)	69 (13.8)	52 (10.5)	61 (13.0)	44 (9.9)	73 (14.3)	86 (17.4)	84 (17.6)	61 (13.4)	47 (11.4)	<0.001
1-year mortality, n (%)	5513 (72.3)	373 (71.3)	351 (75.3)	313 (74.2)	301 (69.7)	335 (73.6)	359 (68.6)	388 (70.7)	353 (70.7)	367 (74.4)	327 (69.7)	343 (76.9)	371 (72.6)	350 (70.9)	346 (72.5)	338 (74.1)	298 (72.2)	0.36

Abbreviations: CABG, coronary artery bypass grafting; decr., decreasing; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; incr., increasing; IQR, interquartile range; MI, myocardial infarction; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; SD, standard deviation; STEMI, ST-segment elevation myocardial infarction logistical solutions. One of them might be direct transfer of patients to specialized centers called Cardiac Shock Centers. These centers should provide access not only to catheterization laboratories but also to the highest level of specialized care and cardiothoracic surgery [11–13]. A network of such centers seems necessary in Poland [11, 12].

It should be noted that this study has some limitations. First, the analyses included all-cause mortality. Second, it is impossible to establish a causal relationship due to the lack of multivariate analyses.

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