ORIGINAL ARTICLE

# Treatment and outcomes of patients under 40 years of age with acute myocardial infarction in Poland in 2009–2013: an analysis from the PL-ACS registry

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**KEY WORDS**

acute myocardial infarction, temporal trends, young age, 12-month outcomes

**ABSTRACT**

**INTRODUCTION** Patients under the age of 40 years represent from 1% to 6% of all patients with acute myocardial infarction (AMI).

**OBJECTIVES** We aimed to analyze the recent trends in the clinical presentation, treatment, and both the in-hospital and 12-month outcomes of patients under 40 years of age with ST-segment elevation myocardial infarction (STEMI) and non-STEMI (NSTEMI), treated from 2009 to 2013.

**PATIENTS AND METHODS** The study included 1639 young patients with AMI under the age of 40 years included in the PL-ACS registry (1.3% of all patients with AMI). Trends in the period from 2009 to 2010 (643 patients) and from 2012 to 2013 (676 patients) were analyzed.

**RESULTS** The percentage of admissions for STEMI decreased (71.7% vs 63.9%; $P = 0.002$), while that of admissions for NSTEMI increased (28.3% vs 36.1%; $P = 0.002$) over the years. There was no difference in the in-hospital mortality (1.7% vs 1.6%; $P = 1.0$). The percentage of patients treated invasively increased from 90.7% in the period 2009–2010 to 95.7% in the period 2012–2013 ($P = 0.0003$). There was no difference between the groups in the incidence of death (2.5% vs 2.8%; $P = 0.72$) or the rate of the composite endpoint of death, recurrent AMI, or stroke within 1 year of the index hospitalization (5.3% vs 5.6%, $P = 0.80$).

**CONCLUSIONS** There was no significant difference in the in-hospital and 12-month outcomes between the patients under 40 years of age with STEMI and NSTEMI hospitalized in the years 2009–2010 and those treated in the years 2012–2013. The relative percentage of patients with NSTEMI and those treated invasively increased significantly over the years.

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**INTRODUCTION** In recent years, the invasive treatment of acute coronary syndrome (ACS) has become more popular in Poland and other European countries.[1,2] Similarly, the changes in the proportion of ST-segment elevation myocardial infarction (STEMI), non-STEMI (NSTEMI), and unstable angina have also been reported.[3,4] The studies presenting those tendencies focused on the general or older population, while young adults were typically excluded.[3,5] Although patients aged below 40 years represent from 1% to 6% of all patients with acute myocardial infarction (AMI),[6,7] the overall number of young patients with ACS is not significant. Therefore, we aimed to analyze the recent trends in the clinical presentation, treatment methods, and outcomes of patients under 40 years of age with STEMI and NSTEMI in Poland, treated from 2009 to 2013.

**PATIENTS AND METHODS** **Registry design** We used the data from the PL-ACS registry. The design, methods, and logistic aspects of the registry were described previously.[5] The PL-ACS registry is a nationwide, multicenter, prospective study of consecutively hospitalized patients with the entire spectrum of ACS in Poland.[3] The registry is

a joint initiative of the Silesian Center for Heart Diseases and the Polish Ministry of Health. The National Health Fund (Narodowy Fundusz Zdrowia [NFZ]), the nationwide public health insurance institution in Poland, provided the logistic support and follow-up data. Hospitals were invited to enter the registry if they had at least one of the following wards in their structure: coronary care, cardiology, cardiac surgery, internal medicine, or an intensive care unit. If the hospital did not have any of these wards, but admitted at least 10 patients with ACS every year, the center could enter the patients into the registry. According to the protocol, all admitted patients with suspected ACS were screened for eligibility to enter the registry, but they were not enrolled until ACS had been confirmed. Our analysis included only the patients with a confirmed diagnosis of STEMI and NSTEMI.

**Definitions and endpoints** STEMI was defined as the presence of: 1) a typical anginal pain and/or ischemic symptoms at rest lasting more than 20 minutes; 2) ST-segment elevation consistent with myocardial infarction of 2 mm or higher in the adjacent chest leads and/or ST-segment elevation of 1 mm or higher in 2 or more standard leads, or a new left bundle branch block; and 3) positive markers for cardiac necrosis. NSTEMI was defined as: 1) the absence of ST-segment elevation as defined above and 2) positive markers for cardiac necrosis.

Hypertension was defined as repeated systemic blood pressure measurements exceeding 140/90 mm Hg or a treatment with antihypertensive drugs for a known diagnosis of hypertension. Diabetes mellitus was diagnosed on the basis of the fasting plasma glucose level exceeding 125 mg/dl (7.0 mmol/l), a random plasma glucose level exceeding 200 mg/dl (11.1 mmol/l), or a history of diabetes mellitus, including patients treated with a diet, oral medications, or insulin. Hypercholesterolemia was defined as a baseline cholesterol level greater than 200 mg/dl (5.2 mmol/l) and/or a low-density lipoprotein cholesterol level greater than 130 mg/dl (3.4 mmol/l), or a previously diagnosed or treated hypercholesterolemia. Obesity was diagnosed as a body mass index of 30 kg/m$^2$ or higher. Invasive treatment was defined as the performance of coronary angiography during the index hospitalization. Finally, major bleedings were defined as bleeding associated with a drop in the hemoglobin level of more than 0.5 g/l, hematocrit of greater than 15%, bleeding with hemodynamic complications, bleeding requiring a blood transfusion, or retroperitoneal and/or intracranial hemorrhage.

**Data collection** The follow-up data regarding the rates of all-cause mortality, rehospitalization, recurrent ACS, stroke, and subsequent revascularization were obtained from the NFZ. The vital status and follow-up information at 12 months after the STEMI- or NSTEMI-related hospitalization were available for all enrolled patients.

Owing to an expected small number of events in patients under the age of 40 years, the data were analyzed as temporal trends and patients were additionally divided into 2 groups: those treated in the years 2009–2010 and those treated in the years 2012–2013. We assessed the differences in the clinical presentation, treatment, and in-hospital and 12-month outcomes, including the occurrence of a composite endpoint. The composite endpoint involved death, AMI, and stroke within the 12-month follow-up.

**Statistical analysis** Continuous variables were presented as mean (SD), and categorical variables—as counts and percentages. The significance of the time trends in the studied years were calculated using the Jonckheere–Terpstra test for continuous variables and the Cochran–Armitage test for categorical variables. The significance of the difference between the 2 groups were assessed using the *t* test or the $\chi^2$ test, depending on the type of data. A multivariate Cox proportional regression model was used to identify the predictors of the composite endpoint at 12 months, and the results were expressed as hazard ratios and 95% confidence intervals (CIs). A 2-tailed *P* value of 0.05 or lower was considered as significant. Calculations were made using NCSS 11 (Kaysville, Utah, United States) and SPSS 17.0 (Chicago, Illinois, United States).

**RESULTS** From 2009 to 2013, a total of 131 403 patients hospitalized for STEMI and NSTEMI were enrolled into the PL-ACS registry. Among them, 1639 (1.3%) were younger than 40 years of age. The percentage of patients under the age of 40 years out of the overall number of patients with STEMI and NSTEMI in the respective years from 2009 to 2013 was 1.2%, 1.4%, 1.2%, 1.3%, and 1.1%. The changes in the clinical characteristics of those patients during the study are presented in TABLE 1.

The percentage of admissions for STEMI decreased, while that of NSTEMI increased over the study period. The mean patient age remained unchanged and the proportion of men decreased. There was no significant difference in the incidence of risk factors, comorbidities, and in-hospital mortality. Although the clinical presentation on admission did not change, patients with anterior wall infarction were less frequently admitted in the years 2012–2013 than in the years 2009–2010. The in-hospital data are presented in TABLE 2.

There was a significant increase in the percentage of patients treated invasively, reaching 97.2% in 2013. Despite this, the number of percutaneous and surgical revascularizations did not increase significantly. Data on patients aged 40 years or older are presented in Supplementary material. In these patients, the percentage of admissions for NSTEMI and coronary angiographies

**TABLE 1** Baseline demographic and clinical characteristics of the study groups

| Parameter | 2009 (n = 261) | 2010 (n = 382) | 2011 (n = 319) | 2012 (n = 387) | 2013 (n = 290) | Total (N = 1639) | *P* value for trend | 2009–2010 (n = 643) | 2012–2013 (n = 676) | *P* value (2009–2010 vs 2012–2013) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Demographic and clinical characteristics** | | | | | | | | | | |
| STEMI | 186 (71.3) | 275 (72.0) | 205 (64.3) | 249 (64.5) | 183 (63.1) | 1098 (67.0) | 0.004 | 461 (71.7) | 432 (63.9) | 0.002 |
| NSTEMI | 75 (28.7) | 107 (28.0) | 114 (35.7) | 137 (35.5) | 107 (36.9) | 540 (33.0) | 0.002 | 182 (28.3) | 244 (36.1) | 0.002 |
| Age, y, mean (SD) | 35.0 (4.1) | 35.1 (4.0) | 34.9 (3.9) | 35.1 (4.1) | 34.9 (4.3) | 35.0 (4.1) | 0.721 | 35.1 (4.1) | 35.0 (4.2) | 0.89 |
| Women | 45 (17.2) | 57 (14.9) | 64 (20.1) | 82 (21.2) | 54 (18.6) | 302 (18.4) | 0.13 | 102 (15.9) | 135 (20.1) | 0.045 |
| Smoking | 195 (74.7) | 285 (74.6) | 226 (70.8) | 292 (75.6) | 212 (73.1) | 1210 (73.9) | 0.84 | 480 (74.7) | 504 (74.6) | 0.96 |
| Hypertension | 96 (36.8) | 162 (42.4) | 113 (35.4) | 161 (41.6) | 131 (45.2) | 663 (40.5) | 0.10 | 258 (40.1) | 292 (43.1) | 0.26 |
| Hypercholesterolemia | 80 (30.7) | 127 (33.2) | 98 (30.7) | 132 (34.1) | 111 (38.3) | 548 (33.4) | 0.074 | 207 (32.2) | 243 (35.9) | 0.16 |
| Diabetes mellitus | 20 (7.7) | 25 (6.5) | 20 (6.3) | 26 (7.0) | 23 (8.7) | 114 (7.1) | 0.61 | 45 (7.0) | 49 (7.7) | 0.65 |
| Obesity | 55 (21.1) | 76 (19.9) | 64 (20.1) | 77 (19.9) | 66 (22.8) | 338 (20.6) | 0.64 | 131 (20.4) | 143 (21.1) | 0.73 |
| Positive family history of premature CAD | 43 (16.5) | 58 (15.2) | 52 (16.3) | 63 (16.3) | 47 (16.2) | 263 (16.0) | 0.86 | 101 (15.7) | 110 (16.2) | 0.79 |
| Prior MI | 11 (4.2) | 20 (5.2) | 14 (4.4) | 11 (2.8) | 6 (2.1) | 62 (3.8) | 0.019 | 31 (4.8) | 17 (2.5) | 0.03 |
| Prior PCI | 9 (3.4) | 13 (3.4) | 7 (2.2) | 14 (3.6) | 2 (0.7) | 45 (2.7) | 0.098 | 22 (3.4) | 16 (2.4) | 0.25 |
| Prior CABG | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 2 (0.7) | 2 (0.7) | 0.019 | 0 (0.0) | 2 (0.3) | 0.17 |
| Prior stroke | 5 (1.9) | 2 (0.5) | 1 (0.3) | 2 (0.5) | 0 (0.0) | 10 (0.6) | 0.0072 | 7 (1.1) | 2 (0.3) | 0.10 |
| Peripheral artery disease | 1 (0.4) | 6 (1.6) | 2 (0.6) | 2 (0.5) | 2 (0.7) | 13 (0.8) | 0.61 | 7 (1.1) | 4 (0.6) | 0.37 |
| COPD | 1 (0.4) | 3 (0.8) | 1 (0.3) | 2 (0.5) | 0 (0.0) | 7 (0.4) | 0.36 | 4 (0.6) | 2 (0.3) | 0.44 |
| **Clinical presentation on admission** | | | | | | | | | | |
| Prehospital cardiac arrest | 3 (1.1) | 5 (1.3) | 6 (1.9) | 6 (1.6) | 6 (2.1) | 26 (1.6) | 0.38 | 8 (1.2) | 12 (1.8) | 0.43 |
| Killip class 3 | 1 (0.4) | 4 (1.0) | 0 (0.0) | 0 (0.0) | 3 (1.0) | 8 (0.5) | 0.94 | 5 (0.8) | 3 (0.4) | 0.49 |
| Killip class 4 | 3 (1.1) | 9 (2.4) | 8 (2.5) | 7 (1.8) | 4 (1.4) | 31 (1.9) | 0.87 | 12 (1.9) | 11 (1.6) | 0.74 |
| Atrial fibrillation | 1 (0.4) | 3 (0.8) | 2 (0.6) | 5 (1.3) | 1 (0.3) | 12 (0.7) | 0.74 | 4 (0.6) | 6 (0.9) | 0.73 |
| Anterior wall location, n/N (%) | 86/186 (46.2) | 128/276 (46.4) | 88/205 (42.9) | 126/250 (50.4) | 106/185 (57.3) | 534/1102 (48.5) | 0.01 | 214/462 (46.3) | 232/435 (53.3) | 0.04 |

Data are presented as number (percentage) of patients unless indicated otherwise.

Abbreviations: CAD, coronary artery disease; CABG, coronary artery bypass graft; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; PCI, percutaneous coronary intervention; NSTEMI, non-ST elevation myocardial infarction; STEMI, ST-segment elevation myocardial infarction

also increased in the years 2009–2013. Moreover, the incidence of some risk factors increased in older patients over the years. The long-term results of young patients who survived the index hospitalization are presented in TABLE 3. We did not observe any significant difference between the groups in the rate of deaths, reinfarctions, strokes, and subsequent revascularization in the postdischarge period. Interestingly, only fewer than one third of the patients had cardiac rehabilitation after the index hospitalization. The 12-month in-hospital outcomes are presented in FIGURES 1 and 2. There were no significant differences during the years in the rate of death, myocardial infarction, stroke, and the composite endpoint in young patients. However, there was a significant decrease in the rate of myocardial infarction and the composite endpoint in patients aged 40 years or older in the years 2009–2013 (Supplementary material). The strongest independent risk factors increasing the 12-month risk of the composite endpoint in patients under the age of 40 years were Killip class 3 or 4 on admission (hazard ratio [HR], 6.82; 95% CI, 3.44–13.52; $P$ <0.0001) and every 5% reduction of left ventricular ejection fraction (HR, 1.29; 95% CI, 1.16–1.43; $P$ <0.0001) assessed during hospitalization for AMI (TABLE 4).

**TABLE 2** In-hospital procedures, treatment, and outcomes depending on the year of analysis

| Parameter | 2009 (n = 261) | 2010 (n = 382) | 2011 (n = 319) | 2012 (n = 387) | 2013 (n = 290) | Total (N = 1639) | *P* value for trend | 2009–2010 (n = 643) | 2012–2013 (n = 676) | *P* value (2009–2010 vs 2012–2013) |
|---|---|---|---|---|---|---|---|---|---|---|
| **In-hospital procedures** | | | | | | | | | | |
| Invasive strategy (coronary angiography) | 228 (87.4) | 355 (92.9) | 310 (97.2) | 366 (94.6) | 282 (97.2) | 1541 (94.0) | <0.0001 | 583 (90.7) | 648 (95.7) | 0.0003 |
| PCI | 177 (67.8) | 277 (72.5) | 223 (69.9) | 286 (73.9) | 214 (73.8) | 1177 (71.8) | 0.062 | 454 (70.6) | 500 (73.9) | 0.19 |
| Thrombolysis | 3 (1.1) | 0 (0.0) | 0 (0.0) | 2 (0.5) | 5 (1.9) | 10 (0.6) | 0.15 | 3 (0.5) | 7 (1.1) | 0.22 |
| CABG | 4 (1.5) | 5 (1.3) | 3 (0.9) | 5 (1.3) | 2 (0.7) | 19 (1.2) | 0.41 | 9 (1.4) | 7 (1.0) | 0.54 |
| No revascularization | 83 (31.8) | 100 (26.2) | 94 (29.5) | 96 (24.8) | 74 (25.5) | 447 (27.3) | 0.11 | 183 (28.5) | 170 (25.1) | 0.17 |
| **In-hospital medications** | | | | | | | | | | |
| Aspirin | 229 (87.7) | 342 (89.5) | 273 (85.6) | 337 (87.1) | 237 (81.7) | 1418 (86.5) | 0.009 | 571 (88.8) | 574 (84.8) | 0.31 |
| Thienopyridines | 256 (98.1) | 376 (98.4) | 315 (98.7) | 378 (97.7) | 280 (96.6) | 1605 (97.9) | 0.13 | 632 (98.3) | 658 (97.2) | 0.18 |
| Glycoprotein IIb/IIIa inhibitor | 77 (29.5) | 137 (35.9) | 97 (30.4) | 141 (36.4) | 115 (39.7) | 567 (34.6) | 0.0121 | 214 (33.3) | 256 (37.8) | 0.09 |
| Unfractionated heparin | 83 (31.8) | 130 (34.0) | 97 (30.4) | 115 (29.7) | 84 (29.0) | 509 (31.1) | 0.19 | 213 (33.1) | 199 (29.4) | 0.14 |
| LWMH | 56 (21.5) | 66 (17.3) | 52 (16.3) | 65 (16.8) | 43 (14.8) | 282 (17.2) | 0.032 | 122 (19.0) | 108 (16.0) | 0.14 |
| β-Blockers | 192 (73.6) | 269 (70.4) | 217 (68.0) | 272 (70.3) | 175 (60.3) | 1125 (68.6) | 0.002 | 461 (71.7) | 447 (66.0) | 0.03 |
| ACEIs | 174 (66.7) | 241 (63.1) | 172 (53.9) | 234 (60.5) | 148 (51.0) | 969 (59.1) | 0.0002 | 415 (64.5) | 382 (56.4) | 0.003 |
| Diuretics | 18 (6.9) | 25 (6.5) | 16 (5.0) | 38 (9.8) | 19 (6.6) | 116 (7.1) | 0.45 | 43 (6.7) | 57 (8.4) | 0.23 |
| Statins | 201 (77.0) | 280 (73.3) | 223 (69.9) | 286 (73.9) | 186 (64.1) | 1176 (71.8) | 0.002 | 481 (74.8) | 472 (69.7) | 0.04 |
| Fibrate | 9 (3.4) | 5 (1.3) | 6 (1.9) | 2 (0.5) | 2 (0.7) | 24 (1.5) | 0.0032 | 14 (2.2) | 4 (0.6) | 0.01 |
| Nitrate | 29 (11.1) | 33 (8.6) | 21 (6.6) | 31 (8.0) | 17 (5.9) | 131 (8.0) | 0.018 | 62 (9.6) | 48 (7.1) | 0.09 |
| Calcium antagonists | 12 (4.6) | 19 (5.0) | 23 (7.2) | 23 (5.9) | 16 (5.5) | 93 (5.7) | 0.50 | 31 (4.8) | 39 (5.8) | 0.45 |
| **In-hospital outcomes** | | | | | | | | | | |
| LVEF <35% | 8 (4.1) | 24 (8.1) | 17 (6.8) | 14 (4.4) | 15 (5.9) | 78 (5.9) | 0.73 | 32 (6.5) | 29 (5.1) | 0.97 |
| Cardiogenic shock | 3 (1.1) | 7 (1.8) | 3 (0.9) | 0 (0.0) | 2 (0.7) | 15 (0.9) | 0.032 | 10 (1.6) | 2 (0.3) | 0.019 |
| IABP | 3 (1.1) | 4 (1.0) | 3 (0.9) | 0 (0.0) | 1 (0.3) | 11 (0.7) | 0.029 | 7 (1.1) | 1 (0.1) | 0.034 |
| Cardiac arrest | 6 (2.3) | 5 (1.3) | 5 (1.6) | 6 (1.6) | 4 (1.4) | 26 (1.6) | 0.56 | 1 1 (1.7) | 10 (1.5) | 0.83 |
| Recurrent MI | 1 (0.4) | 1 (0.3) | 0 (0.0) | 1 (0.3) | 0 (0.0) | 3 (0.2) | 0.36 | 2 (0.3) | 1 (0.1) | 0.61 |
| Major bleeding | 4 (1.5) | 2 (0.5) | 1 (0.3) | 1 (0.3) | 0 (0.0) | 8 (0.5) | 0.007 | 6 (0.9) | 1 (0.1) | 0.06 |
| Death | 4 (1.5) | 7 (1.8) | 5 (1.6) | 4 (1.0) | 7 (2.4) | 27 (1.6) | 0.28 | 11 (1.7) | 11 (1.6) | 1.0 |

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; IABP, intra-aortic balloon pump; LVEF, left ventricular ejection fraction; LWMH, low--weight-molecular heparin; MI, myocardial infarction; others, see **TABLE 1**

**DISCUSSION** An improvement in the treatment of patients with ACS has been observed in Poland over the past years.[1,4,5] The access to one of the largest European databases of patients with ACS has given us the opportunity to investigate, in a reliable manner, the clinical characteristics and treatment outcomes of patients encountered in general practice. We focused on young patients, who seem to constitute a group that is probably the most exposed to the socioeconomic changes observed in Poland in the last years. Patients under the age of 40 years represent from 1% to 6% of all patients with AMI.[6-8] Our study group is the most numerous population of young patients with ACS reported in the literature. Differences in the incidence of ACS are mostly related to the exposure to risk factors of coronary artery disease. In our study, patients under the age of 40 years comprised only 1.3% of all patients with AMI.

Most young patients with AMI experience STEMI.[8-11] In the analysis by Schoenberger et al,[9] 73.1% of the patients aged 35 years or younger

**TABLE 3** Postdischarge outcomes depending on the year of analysis

| Outcome | 2009 (n = 257) | 2010 (n = 375) | 2011 (n = 314) | 2012 (n = 383) | 2013 (n = 283) | Total (N = 1612) | *P* value for trend | 2009–2010 (n = 643) | 2012–2013 (n = 676) | *P* value (2009–2010 vs 2012–2013) |
|---|---|---|---|---|---|---|---|---|---|---|
| 30-day mortality | 0 (0.0) | 0 (0.0) | 2 (0.6) | 1 (0.3) | 0 (0.0) | 3 (0.2) | 0.70 | 0 (0.0) | 1 (0.2) | 1.0 |
| 3-month mortality | 0 (0.0) | 1 (0.3) | 3 (1.0) | 3 (0.8) | 2 (0.7) | 9 (0.6) | 0.16 | 1 (0.2) | 5 (0.8) | 0.21 |
| 6-month mortality | 2 (0.8%) | 1 (0.3) | 3 (1.0) | 3 (0.8) | 2 (0.7) | 11 (0.7) | 0.72 | 3 (0.5) | 5 (0.8) | 0.72 |
| 12-month mortality | 4 (1.6) | 1 (0.3) | 4 (1.3) | 5 (1.3) | 3 (1.1) | 17 (1.1) | 0.80 | 5 (0.8) | 8 (1.2) | 0.58 |
| Reinfarction at 12 months | 6 (2.3) | 9 (2.4) | 4 (1.3) | 14 (3.7) | 7 (2.5) | 40 (2.5) | 0.51 | 15 (2.4) | 21 (3.2) | 0.39 |
| Stroke at 12 months | 0 (0.0) | 1 (0.3) | 2 (0.6) | 0 (0.0) | 0 (0.0) | 3 (0.2) | 0.63 | 1 (0.2) | 0 (0.0) | 0.49 |
| PCI at 12 months | 32 (12.5) | 33 (8.8) | 29 (9.2) | 46 (12.0) | 42 (14.8) | 182 (11.3) | 0.12 | 65 (10.3) | 88 (13.2) | 0.10 |
| CABG at 12 months | 4 (1.6) | 5 (1.3) | 3 (1.0) | 4 (1.0) | 4 (1.4) | 20 (1.2) | 0.77 | 9 (1.4) | 8 (1.2) | 0.72 |
| Cardiac rehabilitation during 6 months | 84 (32.7) | 110 (29.3) | 84 (26.8) | 92 (24.0) | 87 (30.7) | 457 (28.3) | 0.23 | 194 (30.7) | 179 (26.9) | 0.12 |
| Cardiac rehabilitation during 12 months | 85 (33.1) | 113 (30.1) | 84 (26.8) | 92 (24.0) | 87 (30.7) | 461 (28.6) | 0.16 | 198 (31.3) | 179 (26.9) | 0.08 |

Abbreviations: see **TABLE 1**

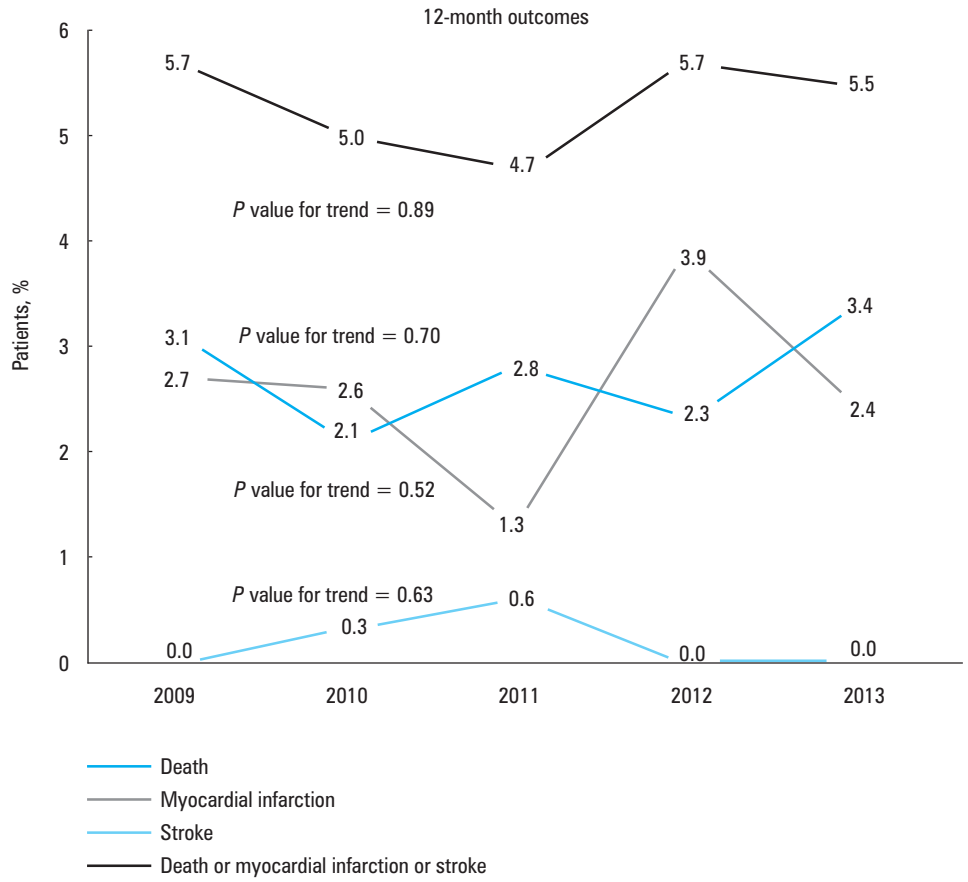


**FIGURE 1** Twelve--month in-hospital outcomes in patients under the age of 40 admitted due to acute myocardial infarction in the years from 2009 to 2013

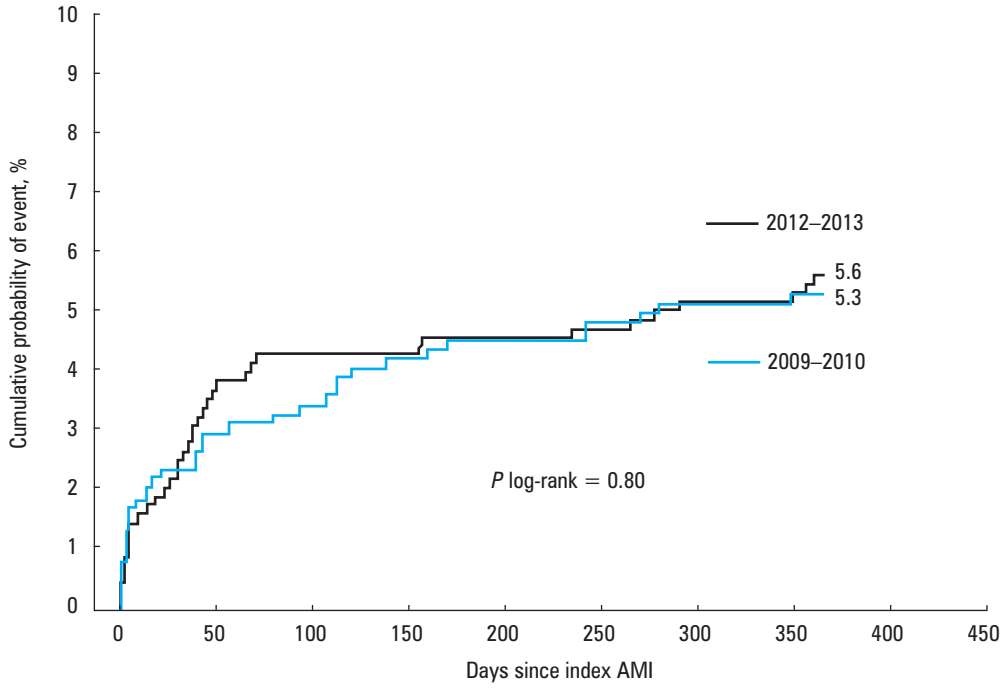


**FIGURE 2** Survival curves for the composite endpoint of death, myocardial infarction, or stroke during the 12-month hospitalization of patients admitted due to acute myocardial infarction (in the years 2009–2010 and 2012–2013)

**TABLE 4** Independent predictors of the composite endpoint at 12 months in patients with acute myocardial infarction aged under 40 years of age

| Parameters | Wald $\chi^2$ | HR (95% CI) | *P* value |
|---|---|---|---|
| Killip class 3 or 4 on admission | 30.29 | 6.82 (3.44–13.52) | <0.0001 |
| LVEF (per 5% less) | 21.95 | 1.29 (1.16–1.43) | <0.0001 |
| Obesity | 6.41 | 0.40 (0.20–0.82) | 0.011 |
| Diabetes mellitus | 5.97 | 2.24 (1.17–4.28) | 0.014 |
| COPD | 5.92 | 6.08 (1.42–26.02) | 0.015 |
| Age (per 1 year more) | 5.12 | 1.08 (1.01–1.15) | 0.024 |

Abbreviations: CI, confidence interval; HR, hazard ratio; others, see TABLES 1 and 2

with ACS were admitted to the hospital because of STEMI.[9] In the Thai ACS Registry,[10] STEMI was diagnosed in 67% of the patients under 45 years of age. In our study, 67% of the patients below 40 years had STEMI. Moreover, the frequency of hospital admissions for NSTEMI has increased in the general population over the recent years,[3,4] which is consistent with our observations. From 2009 to 2013, the rate of hospitalizations for NSTEMI increased by 7%. It might result from a wide use of high-sensitivity troponin and a consistently higher number of patients with NSTEMI. A dynamic increase in the incidence of NSTEMI and the rate of coronary angiographies was not related with an increase in the rate of revascularization procedures. An increase in the number of admissions for NSTEMI and coronary angiographies was observed also in patients aged 40 years or older. However, unlike in young patients, it was associated with an increased number of revascularization procedures.

As mentioned earlier, the incidence of AMI in younger patients is associated with a higher prevalence of some cardiovascular risk factors. The most prevalent risk factors for this age group usually include smoking, hypercholesterolemia, a positive family history of premature coronary artery disease, and hypertension.[7-10,12-15] In our study, the most common risk factors over the years consistently included smoking, hypertension, and hypercholesterolemia. In earlier studies, smoking was reported in more than 90% of younger[16,17] and in 40% of older patients with AMI.[7] Although the decline in the number of smokers has been observed in Poland in the recent years,[18] this tendency has not been demonstrated in our study. Moreover, in another study conducted by our group and based on the PL-ACS registry, smokers constituted 60.1% of the patients with ACS aged below 40 years and treated between 2003 and 2009.[8] This confirms that smoking remains one of the strongest factors of premature AMI in young adults.

The second most frequent risk factor reported in the majority of studies is hypercholesterolemia[8,9,13-16] or hypertension.[8,15] The incidence of hypercholesterolemia or dyslipidemia in the published studies differs according to the criteria and ranges from 20% to nearly 75%.[6,9,10,13] The growth in the incidence rate of hypercholesterolemia over the years is mainly related with less restrictive criteria of its diagnosis. The role of

hypercholesterolemia is still underestimated.[19,20] The second frequent risk factor in our study was hypertension, observed in over 40% of the patients. The incidence of hypertension in young patients with AMI seems to have increased over the years. Garoufalis et al[14] noted hypertension in 7% of patients with AMI aged 45 years or younger. In a study by Yunyun et al,[21] hypertension was present in 47.7% of young patients with AMI aged 44 years or younger and treated between 2009 and 2013. Khawaja et al[22] studied patients aged 50 years or younger who underwent percutaneous coronary intervention. The authors reported an increase in the incidence of hypertension from 29% in the years 1981–1989 to 57% in the years 2000–2007.[22] We did not observe any significant change in the incidence rate of risk factors, which may be due to a relatively short study period.

Our in-hospital treatment was consistent with the guidelines of the European Society of Cardiology, recommending a revascularization therapy for patients with STEMI and NSTEMI.[23,24] A dense network of cardiac catherization laboratories in Poland made it possible to increase the rate of coronary angiographies to more than 95% in patients treated in the years 2012–2013. Despite the above percentage of revascularization procedures, the short- and long-term results remained unchanged. Nearly all patients in our study were treated with thienopyridines. The decreasing rate of patients treated with β-blockers, angiotensin-converting enzyme inhibitors, and lipid-lowering drugs in the years 2012–2013 is quite surprising. Our short-term results are consistent with our previous studies comprising participants of the PL-ACS registry and reporting an in-hospital mortality rate of less than 2.0% in young patients with ACS or AMI.[8,25] Fournier et al[16] reported an in-hospital mortality rate of 3.7% in patients with AMI aged 40 years or younger and treated in the years 1986–1992.[16] In the Spanish multicenter observational study PRIAMHO II, including patients with AMI aged below 45 years and treated in 58 hospitals in 2000, the mortality rate at 28 days was 3.7%.[11] We observed an increase in the number of women with AMI. Some studies documented a significant longer time delay to reperfusion in women compared with men.[26,27] Vaccarino et al[28] showed that young women who survived AMI had the mortality rate about 50% higher than men 2 years after infarction. Sadowski et al[25] observed similar in-hospital results and higher 12-month mortality after STEMI in young women in comparison with men enrolled to the PL-ACS registry.[25]

Despite good accessibility of invasive treatment, only fewer than one-third of the patients underwent cardiac rehabilitation during 6 and 12 months after STEMI or NSTEMI. The availability of cardiac rehabilitation in patients after ACS is still below expectations in Poland.[29] In another Polish analysis, only 18% of patients with ACS or cardiac surgery had rehabilitation during 6 months after the index hospitalization.[29] Although postinfarction rehabilitation was available for a limited number of patients, 12-month results were satisfactory and did not differ between the analyzed periods. We demonstrated satisfactory distant results in both analyzed periods. It is worth emphasizing that most patients were treated invasively, received guideline-recommended therapy, and had low incidence of other comorbidities. Similarly to other studies, our multivariate analysis indicated that Killip class 3 or 4 on admission and every 5% reduction of left ventricular ejection fraction were the strongest independent risk factors increasing the 12-month incidence of the composite endpoint.[8,30] In conclusion, our study showed that there was no significant difference in the incidence of risk factors, comorbidities, and in-hospital and 12-month outcomes between patients younger than 40 years with STEMI and NSTEMI hospitalized in the years 2009–2010 compared with those treated in the years 2012–2013. The percentage of patients with NSTEMI and that of performed coronary angiographies significantly increased over the years.

Our study has several limitations. First, some risk factors predisposing to premature AMI but not included in the registry were familial hypercholesterolemia, autoimmune diseases, connective tissue disorders, neoplastic diseases, and hypercoagulable states. Additionally, in some cases, especially in young patients, AMI can be the consequence of cocaine-induced coronary spasms.[31] Drug addiction, especially cocaine abuse, is not a relevant factor in Poland and, consequently, was not included in the registry dataset. Moreover, the time interval between the 2 analyzed periods was not long. Finally, the number of adverse cardiac events during the follow-up was small and thus their potential changes over the years were difficult to assess in our analysis.

**Supplementary material** Supplementary material is available with the article at www.pamw.pl.

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