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WHAT'S NEW?

Acute myocardial infarction (AMI) in young patients is often a slightly different disease than in older patients. The prevention of acute myocardial infarction in a young patient should primarily focus on smoking cessation. The left anterior descending artery is the most common infarct-related artery in young patients. The additional diagnostic tools should be considered during angiography to diagnose the reasons for AMI other than atherosclerosis. The relative number of AMI in young patients is growing.

ABSTRACT

Background: Acute myocardial infarction (AMI) is an incredibly destructive disease when it occurs in a young patient. Thus the investigation of the disease presentation and treatment options seem to be particularly important in young patients with AMI.
Aims: The study objective was to investigate the differences between young and older patients diagnosed with AMI in terms of clinical characteristics and treatment strategies.

Methods: The patient data come from the National Registry of Procedures of Invasive Cardiology (ORPKI, Ogólnopolski Rejestr Procedur Kardiologii Inwazyjnej). Between 2014 and 2017, the data of more than 230 000 patients with a diagnosis of AMI were collected in that registry. The young patients were defined as under 40 years old.

Results: Young patients with AMI compared with older patients with AMI were more often men (86.3% vs 65.8%; *P* <0.001) with higher body weight (mean 85.9 vs 79.7 kg; *P* <0.001). Young patients with AMI were more often diagnosed with ST-segment elevation myocardial infarction (STEMI; 62.0% vs 50.0%; *P* <0.001). Moreover, they had more frequently non-significant stenosis in coronary arteries diagnosed (14.4% vs 6.8%; *P* <0.001). The left anterior descending artery was more frequent an infarct-related artery in young patients (51.3% vs 36.3%; *P* <0.001). Bioresorbable vascular scaffolds were more commonly implanted in young patients with AMI than in older ones (5.6% vs 0.9%; *P* <0.001).

Conclusions: Smoking is the most common risk factor in young adults. The relative number of AMI in young patients is growing.

Key words: acute myocardial infarction, angiography, coronary artery disease, percutaneous coronary intervention

INTRODUCTION

Acute myocardial infarction (AMI) is one of the leading causes of mortality in the Polish population. Thus, many efforts are directed towards the primary prevention of coronary artery disease, and fast diagnostic methods are used. The network of invasive cardiology centers is developed to provide the optimal diagnostic and treatment options for the whole population.

In recent years, the relative incidence of ST-segment elevation myocardial infarction (STEMI) has been decreasing, while the relative incidence of non-ST-segment elevation myocardial infarction (NSTEMI) has been expanding [1]. AMI is an incredibly destructive disease, especially when it occurs in a young patient. It is associated with significant morbidity, psychological consequences, and financial restraints for the patient and the family. Thus, the investigation of the AMI causes, presentation, and management options seems to be particularly important in young patients.

METHODS

The data analyzed in this publication come from the National Registry of Procedures of Invasive Cardiology (ORPKI). ORPKI is a Polish national registry that collects data on percutaneous

procedures in invasive cardiology performed in 163 cardiac catheterization laboratories and invasive cardiology departments. From January 1, 2014, the Jagiellonian University Collegium Medicum in Krakow is the entity responsible for maintaining the database. ORPKI registry design and details have been previously published [2, 3]. Because of the data character (registry of procedures), the ethics committee approval or patient's written informed consent to participate in the registry was not required.

The study investigated the differences in patients' characteristics and the disease presentation and treatment between young and older patients. The young patients were defined as under 40 years old.

Statistical analysis

Categorical variables were presented as numbers and percentages. Continuous variables were expressed as mean, standard deviation (SD), median, and interquartile range (IQR). The Mann-Whitney U test was used to compare differences between groups, although age and weight of subjects were compared using the Welch's t-test. Normality was assessed by the Kolmogorov-Smirnov-Lilliefors test (or by the Shapiro-Wilk test for less than 2000 observations). Ordinal variables were compared by Cochran-Armitage test for trend or Mann-Whitney U test. Categorical variables were compared by Pearson's chi-squared test or Fisher's exact test if 20% of cells had an expected count of less than 5.

The linear regression model was created to investigate a trend in quarter data of the percentage of young patients' procedures. The Shapiro-Wilk test checked the normality of model residuals. To check heteroscedasticity, the Brown-Forsythe test was used to examine whether the upper half's residuals had different variability than those in the lower half (median split). The Durbin-Watson test checked the autocorrelation of residuals.

Two-sided *P*-values <0.05 were considered statistically significant. All calculations were performed with JMP®, Version 14.2.0 (SAS Institute Inc., Cary, NC, USA).

RESULTS

The data of 237 747 patients with a diagnosis of myocardial infarction were collected in the ORPKI Registry between 2014 and 2017. In that group, 3 208 (1.3%) patients were under 40 years old (mean [SD] age, 34.5 [4.6] vs 67.3 [11.3] years).

Young patients with myocardial infarction were more frequently men with significantly higher body weight than their older counterparts (Table 1). Typical risk factors of coronary heart disease in young patients were slightly different from those in the older population, namely

diabetes mellitus, arterial hypertension, and chronic kidney disease were less frequent in younger patients than in older patients. However, in the under 40 years old group, there was a significantly higher number of current smokers. Detailed data regarding the medical history of both groups of patients are presented in Table 2.

Based on patient characteristics on admission to the hospital (Table 3), young patients with AMI had significantly more often diagnosed STEMI with cardiac arrest during the index hospitalization. Even though the rate of direct transport to the primary Percutaneous Coronary Interventions (PCI) center was similar in both groups, the time delays from symptoms onset to the treatment were lower in the younger group (Table 4).

Radial access was used more frequently in a group of young patients. Still, additional diagnostic devices like intravascular ultrasound (IVUS), optical coherence tomography (OCT), or fractional flow reserve (FFR) were used with similar frequency in both study groups. Moreover, young patients had more frequently non-significant stenosis in coronary arteries and a single-vessel disease when significant lesions were diagnosed (Table 5).

During the PCI procedure, aspiration thrombectomy was used in young patients twice as often as in their older counterparts (Table 6). Moreover, young patients received thrombolytic therapy more often, and new antiplatelet agents were used more frequently than in the older group. In more than half of the young patients, an infarct-related artery was left anterior descending (LAD, Table 7). Drug-eluting stents (DES) were used with similar frequency in both study groups, but bare-metal stents (BMS) were implanted more often in older patients. On the contrary, bioresorbable vascular scaffolds (BVS) were more commonly chosen for young patients (Supplementary material, *Table S1*). The percentage of patients with the final complete flow (TIMI grade 3 flow) in the infarct-related artery was similar in both groups. Even though younger patients have higher body weight than the older ones, the total amount of contrast and total radiation dose during the procedures were lower in the under 40 years old group (Table 8). The frequency of periprocedural complications during coronary angiographies and PCI procedures was relatively small and similar in both study groups (Supplementary material, *Table S2*).

The absolute numbers of AMI decreased from year to year, but the relative amount of AMI in young patients increased from 1.20% in 2014 to 1.43% in 2017. This surge is statistically significant when calculated quarterly (β = 0.0240; 95% CI, 0.0051–0.0429; P = 0.02; R^2 = 34.66%).

DISCUSSION

According to our study, AMI in young patients seems to be a slightly different medical problem than in older patients. These differences could be observed in several distinct areas. When it comes to demographic data, a typical young patient with AMI is a smoking man. A similar observation was found in other studies [4–6]. Other specific AMI risk factors — like arterial hypertension, diabetes mellitus, or chronic kidney disease are more often observed in older patients with AMI. Our results are concordant with the results of Chhabra et al. [7]. As we know from previously published studies, the correlation of even one risk factor with the patient's age may significantly affect his prognosis [12]. Apart from the abovementioned, a significant risk factor of AMI, especially in young patients, is familial hypercholesterolemia. Due to the nature of the data, it was not possible to assess this risk factor's occurrence in our study population. Clinically, in young patients with AMI, STEMI is more prevalent [1]. It was also described that in young patients with AMI, a significant coronary artery stenosis is observed more frequently in LAD than in other arteries [8], which is concordant with our findings.

Unfortunately, because of the data character (registry), it is impossible to distinguish between true atherosclerotic lesions and spontaneous coronary artery dissection (SCAD), which might be an underlying cause of AMI, especially in young women. Similarly, the domination of non-significant lesions and one-vessel disease in young patients was described previously in the Russian population [9]. Patients with non-significant lesions on coronary angiography, as well as with no evidence of atherosclerosis, but with the diagnosis of myocardial infarction (MINOCA, almost 35% of young patients in contrary to the older ones — 9%) are eventual candidates for extended diagnostic workup of coronary arteries, like IVUS or OCT. Unfortunately, this management was rarely reported in our registry (approx. 0.3%). Even though our patients' groups had similar rates regarding the periprocedural complications, the extended follow-up results may differ. As it was published previously, early coronary artery disease (CAD) is strongly associated with AMI and death within 30 days of presentation in patients hospitalized due to chest pain [10].

In comparison to older patients with AMI, in patients under 40 years old with this medical condition, the reason for their troponin elevation is more often not so obvious. It may require the use of more sophisticated diagnostic tools. In long-term follow-up, in young patients with AMI, the risk of myocardial ischemia recurrence may be higher when not applying them. Close follow-up and post-hospital cardiac control, the positive effects of which have been studied and described [13], seem to be particularly justified in the group of young patients with AMI.

CONCLUSION

AMI in young patients (defined as under 40 years old) is a different disease than in their older counterparts. The younger patients with AMI have distinct risk factors profiles and angiographic findings in coronary arteries. The primary prevention of AMI in young patients should mainly focus on smoking cessation. During coronary angiography, the additional diagnostic tools, as IVUS, OCT, or microvascular examination, should be considered, as the reasons other than atherosclerosis are particularly frequent in this group of patients.

Limitations

Despite a relatively large group of patients, the data acquisition methodology (ORPKI registry) does not allow to collect data regarding familial hypercholesterolemia or hyperuricemia, which may play a role in the development of coronary artery disease [11]. We could not perform a standardized analysis of patient angiography, so it was not possible to assess the role of muscle bridge in LAD stenosis and SCAD.

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Table 1. Demographic data — summary

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
Year	N	3208	234539	237747	CA	<0.001
	2014	882 (27.49%)	72612 (30.96%)	73494 (30.91%)		
	2015	827 (25.78%)	61347 (26.16%)	62174 (26.15%)		
	2016	782 (24.38%)	51185 (21.82%)	51967 (21.86%)		
	2017	717 (22.35%)	49395 (21.06%)	50112 (21.08%)		
Age, years	N	3208	234539	237747	W	<0.001
	Mean (SD)	34.53 (4.57)	67.25 (11.29)	66.81 (11.85)		
Gender	N	3166	232788	235954	P	<0.001
	Female	435 (13.74%)	79699 (34.24%)	80134 (33.96%)		
	Male	2731 (86.26%)	153089 (65.76%)	155820 (66.04%)		
Weight, kg	N	3208	234539	237747	W	<0.001
	Mean (SD)	85.94 (18.89)	79.73 (17.37)	79.81 (17.40)		

CA, Cochran-Armitage test; P, Pearson’s chi-squared test; W, Welch’s t-test

Table 2. Myocardial infarction (MI) risk factors

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
Diabetes	N	3208	234539	237747	P	<0.001
	Yes	171 (5.33%)	53106 (22.64%)	53277 (22.41%)		
	No	3037 (94.67%)	181433 (77.36%)	184470 (77.59%)		
Previous stroke	N	3208	234539	237747	P	<0.001
	Yes	19 (0.59%)	8845 (3.77%)	8864 (3.73%)		
	No	3189 (99.41%)	225694 (96.23%)	228883 (96.27%)		
Previous MI	N	3208	234539	237747	P	<0.001
	Yes	230 (7.17%)	53269 (22.71%)	53499 (22.50%)		
	No	2978 (92.83%)	181270 (77.29%)	184248 (77.50%)		
Previous PCI	N	3208	234539	237747	P	<0.001
	Yes	225 (7.01%)	52974 (22.59%)	53199 (22.38%)		
	No	2983 (92.99%)	181565 (77.41%)	184548 (77.62%)		
Previous CABG	N	3208	234539	237747	P	<0.001
	Yes	15 (0.47%)	10418 (4.44%)	10433 (4.39%)		
	No	3193 (99.53%)	224121 (95.56%)	227314 (95.61%)		
Smoking status	N	3208	234539	237747	P	<0.001
	Yes	1203 (37.50%)	53878 (22.97%)	55081 (23.17%)		
	No	2005 (62.50%)	180661 (77.03%)	182666 (76.83%)		
Psoriasis	N	3208	234539	237747	P	0.39
	Yes	17 (0.53%)	1009 (0.43%)	1026 (0.43%)		
	No	3191 (99.47%)	233530 (99.57%)	236721 (99.57%)		
Hypertension	N	3208	234539	237747	P	<0.001
	Yes	961	156084	157045		

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
		(29.96%)	(66.55%)	(66.06%)		
	No	2247 (70.04%)	78455 (33.45%)	80702 (33.94%)		
Kidney disease	N	3208	234539	237747	P	<0.001
	Yes	48 (1.50%)	13894 (5.92%)	13942 (5.86%)		
	No	3160 (98.50%)	220645 (94.08%)	223805 (94.14%)		
COPD	N	2374	166443	168817	P	<0.001
	Yes	2 (0.08%)	4654 (2.80%)	4656 (2.76%)		
	No	2372 (99.92%)	161789 (97.20%)	164161 (97.24%)		

CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; PCI, percutaneous coronary intervention; other abbreviations — see Table 1

Table 3. Patient status on admission

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
Killip class IV on admission	N	2468	164245	166713	P	<0.001
	Yes	43 (1.74%)	4800 (2.92%)	4843 (2.90%)		
	No	2425 (98.26%)	159445 (97.08%)	161870 (97.10%)		
Indication	N	3208	234539	237747	P	<0.001
	STEMI	1988 (61.97%)	117264 (50.00%)	119252 (50.16%)		
	NSTEMI	1220 (38.03%)	117275 (50.00%)	118495 (49.84%)		
Cardiac arrest at baseline	N	3035	196878	199913	P	0.03
	Yes	138 (4.55%)	7420 (3.77%)	7558 (3.78%)		
	No	2897 (95.45%)	189458 (96.23%)	192355 (96.22%)		
Hypothermia at baseline	N	3035	196878	199913	F	0.15
	Yes	8 (0.26%)	298 (0.15%)	306 (0.15%)		
	No	3027 (99.74%)	196580 (99.85%)	199607 (99.85%)		
Direct transport	N	3035	196878	199913	P	0.39
	Yes	452 (14.89%)	28230 (14.34%)	28682 (14.35%)		
	No	2583 (85.11%)	168648 (85.66%)	171231 (85.65%)		

F, Fisher's exact test; NSTEMI, non-ST segment elevation myocardial infarction; STEMI, ST-segment elevation myocardial infarction; other abbreviations — see Table 1

Table 4. Reported time delays in patients transport

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
Time from pain to first contact, min	N	2641	170995	173636	U	<0.001
	Median (IQR)	170.00 (60.00–420.00)	180.00 (69.00–480.00)	180.00 (68.00–480.00)		
Time from pain to inflation or angiogram, min	N	2538	173132	175670	U	<0.001
	Median (IQR)	375.00 (180.00–910.75)	480.00 (210.00–1294.75)	480.00 (209.00–1290.00)		
Time from the first contact to inflation or angiogram, min	N	2552	173325	175877	U	<0.001
	Median (IQR)	120.00 (63.00–330.75)	150.00 (73.00–461.00)	150.00 (73.00–460.00)		

IQR, interquartile range; Me, median; U, Mann-Whitney U test; other abbreviations — see Table 1

Table 5. Coronary angiography — procedure details

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
Access site during an angiogram	N	3035	196705	199740	P	<0.001
	Femoral	666 (21.94%)	52123 (26.50%)	52789 (26.43%)		
	Radial right	1905 (62.77%)	112938 (57.41%)	114843 (57.50%)		
	Radial left	456 (15.02%)	30200 (15.35%)	30656 (15.35%)		
	Other	8 (0.26%)	1444 (0.73%)	1452 (0.73%)		
FFR during angiogram	N	3035	196878	199913	P	0.01
	Yes	0 (0.00%)	397 (0.20%)	397 (0.20%)		
	No	3035 (100.00%)	196481 (99.80%)	199516 (99.80%)		
IVUS during angiogram	N	3035	196878	199913	F	0.46
	Yes	6 (0.20%)	287 (0.15%)	293 (0.15%)		
	No	3029 (99.80%)	196591 (99.85%)	199620 (99.85%)		
OCT during angiogram	N	3035	196878	199913	F	0.30
	Yes	2 (0.07%)	70 (0.04%)	72 (0.04%)		
	No	3033 (99.93%)	196808 (99.96%)	199841 (99.96%)		
Results of angiography	N	3034	196518	199552	P	<0.001
	No evidence of atherosclerosis	606 (19.97%)	3640 (1.85%)	4246 (2.13%)		
	Without significant stenosis	438 (14.44%)	13268 (6.75%)	13706 (6.87%)		
	1-vessel disease	1456 (47.99%)	69590 (35.41%)	71046 (35.60%)		

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
	LMCA disease	12 (0.40%)	590 (0.30%)	602 (0.30%)		
	Multivessel disease	480 (15.82%)	90428 (46.02%)	90908 (45.56%)		
	Multivessel and LMCA disease	42 (1.38%)	19002 (9.67%)	19044 (9.54%)		

FFR, fractional flow reserve; IVUS intravascular ultrasonography; LMCA left main coronary artery; OCT optical coherence tomography; other abbreviations — see Table 1 and 3

Table 6. Percutaneous coronary intervention (PCI) — procedure details

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
FFR during PCI	N	2060	198088	200148	P	0.34
	Yes	5 (0.24%)	732 (0.37%)	737 (0.37%)		
	No	2055 (99.76%)	197356 (99.63%)	199411 (99.63%)		
IVUS during PCI	N	2060	198088	200148	P	0.05
	Yes	18 (0.87%)	1099 (0.55%)	1117 (0.56%)		
	No	2042 (99.13%)	196989 (99.45%)	199031 (99.44%)		
OCT during PCI	N	2060	198088	200148	F	0.008
	Yes	7 (0.34%)	211 (0.11%)	218 (0.11%)		
	No	2053 (99.66%)	197877 (99.89%)	199930 (99.89%)		
Aspiration thrombectomy during PCI	N	2060	198088	200148	P	<0.001
	Yes	319 (15.49%)	14447 (7.29%)	14766 (7.38%)		
	No	1741 (84.51%)	183641 (92.71%)	185382 (92.62%)		
Rotablation during PCI	N	2060	198088	200148	P	0.03
	Yes	1 (0.05%)	624 (0.32%)	625 (0.31%)		
	No	2059 (99.95%)	197464 (99.68%)	199523 (99.69%)		
P2Y12 during PCI	N	2060	198088	200148	P	<0.001
	Clopidogrel	651 (31.60%)	73792 (37.25%)	74443 (37.19%)		
	Prasugrel	42 (2.04%)	1190 (0.60%)	1232 (0.62%)		
	Ticagrelor	244	10981	11225		

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
		(11.84%)	(5.54%)	(5.61%)		
	No	1123 (54.51%)	112125 (56.60%)	113248 (56.58%)		
Thrombolysis during PCI	N	2060	198088	200148	P	<0.001
	Yes	17 (0.83%)	533 (0.27%)	550 (0.27%)		
	No	2043 (99.17%)	197555 (99.73%)	199598 (99.73%)		

Abbreviations — see Table 1–3 and 5

Table 7. Percutaneous coronary intervention (PCI) procedure — lesion localization

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
LMCA	N	2060	198088	200148	P	<0.001
	Yes	38 (1.84%)	6396 (3.23%)	6434 (3.21%)		
	No	2022 (98.16%)	191692 (96.77%)	193714 (96.79%)		
RCA	N	2060	198088	200148	P	<0.001
	Yes	516 (25.05%)	63947 (32.28%)	64463 (32.21%)		
	No	1544 (74.95%)	134141 (67.72%)	135685 (67.79%)		
LAD	N	2060	198088	200148	P	<0.001
	Yes	1056 (51.26%)	71949 (36.32%)	73005 (36.48%)		
	No	1004 (48.74%)	126139 (63.68%)	127143 (63.52%)		
Circumflex	N	2060	198088	200148	P	<0.001
	Yes	290 (14.08%)	38253 (19.31%)	38543 (19.26%)		
	No	1770 (85.92%)	159835 (80.69%)	161605 (80.74%)		
SvG	N	2060	198088	200148	P	<0.001
	Yes	1 (0.05%)	2234 (1.13%)	2235 (1.12%)		
	No	2059 (99.95%)	195854 (98.87%)	197913 (98.88%)		
LIMA/RIMA	N	2060	198088	200148	F	0.06
	Yes	0 (0.00%)	348 (0.18%)	348 (0.17%)		
	No	2060 (100.00%)	197740 (99.82%)	199800 (99.83%)		

LAD, left anterior descending artery; LIMA, left internal mammary artery; LMCA, left main coronary artery; RCA, right coronary artery; RIMA, right internal mammary artery; SvG, saphenous vein graft; other abbreviations — see Table 1–3

Table 8. Percutaneous coronary intervention (PCI) procedure — final summary

Variable	Measure/level	Age <40	Age ≥40	Total	Test	*P*-value
TIMI 3 flow after PCI	N	1982	190419	192401	P	0.008
	Yes	1863 (94.00%)	175955 (92.40%)	177818 (92.42%)		
	No	119 (6.00%)	14464 (7.60%)	14583 (7.58%)		
The total amount of contrast used during the procedure, ccm	N	3080	223456	226536	U	<0.001
	Median (IQR)	130.00 (80.00–190.00)	150.00 (100.00–200.00)	150.00 (100.00–200.00)		
Total radiation dose during the procedure, mGy	N	3054	222467	225521	U	<0.001
	Median (IQR)	543.50 (267.75–1126.50)	737.00 (391.00–1316.00)	734.00 (389.00–1313.00)		

ccm, cubic centimeter; mGy, miliGrey; TIMI, thrombolysis in myocardial infarction; other abbreviations — see Table 1 and 2