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Management and predictors of event-free survival in nonagenarians with myocardial infarction: A nationwide analysis

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WHAT'S NEW?

The data concerning factors contributed to long-lived patients' management of myocardial infarction (MI) are limited, therefore the present study investigates the roles of single and combined predictors of mortality in relation to the invasive and non-invasive strategy in nonagenarians. We showed that, when managed invasively, males at least 90 years hospitalized for MI, have lower in-hospital (odds ratio 0.79 [95% CI, 0.70–0.90]), but higher post-discharge mortality (hazard ratio 1.14 [95% CI, 1.03–1.27]) than females. Sex is not an independent predictor of mortality nor morbidity in patients managed conservatively. Invasive management was associated with lower risk of mortality and major adverse events. The managed care may improve prognosis in the oldest old patients. Variables independently related to the higher risk of post-discharge death were age, heart failure, atrial fibrillation, diabetes, and chronic obstructive pulmonary disease. Current findings support a targeted approach for individualisation when planning healthcare for the long-lived patients with MI.

ABSTRACT

Background: Myocardial infarction (MI) remains the leading cause of death, especially in the elderly.

Aims: To characterize management and factors related to event-free survival in patients with acute MI aged at least 90 years.

Methods: We included all patients aged at least 90 years hospitalized for MI in Poland between 2014 and 2020 and followed them for one year.

Results: A total of 14 970 patients (median age 92.7 [90.9–93.8]) were included (4666 men and 10 304 women). Coronary angiography was performed in 47.0% of patients, percutaneous coronary intervention in 39.8%, and coronary artery bypass grafting in 0.2% of patients. In-hospital mortality was 27.8% (25.1% in men and 29.0% in women; P <0.001). Variables independently related to the higher risk of in-hospital death were age and history of stroke, while male sex, hypertension, history of MI and invasive management were related to the lower risk of in-hospital death. One-year all-cause mortality following discharge was 38.1% (females: 38.4%, males: 37.5%; P = 0.27), the endpoint consisting of all-cause death, MI or stroke occurred in 42.6% patients (females: 42.8%, males: 42.2%; P = 0.44), while all-cause death or cardiovascular hospitalization in 59.0% (females: 58.2%, males: 60.7%; P = 0.046). Variables independently related to the higher risk of post-discharge death were age, heart failure, atrial fibrillation, diabetes, and chronic obstructive pulmonary disease. Participation in the managed care programme following MI was linked to a lower risk of death or hospitalization for cardiovascular reasons.

Conclusions: Variables independently related to the higher risk of post-discharge death among patients hospitalized for MI aged at least 90 years were age, heart failure, atrial fibrillation, diabetes, and chronic obstructive pulmonary disease. When managed invasively, males, have lower in-hospital, but higher post-discharge mortality than females.

Key words: cardiovascular events, coronary artery disease, mortality, myocardial infarction, oldest olds, nonagenarians

INTRODUCTION

The management of patients with acute coronary syndrome has significantly improved in recent decades. However, cardiovascular diseases, including myocardial infarction (MI), remain a major health threat worldwide [1]. European Society of Cardiology guidelines recommend coronary artery reperfusion in patients with ST-elevation MI emphasising that, in all situations when it is possible, primary percutaneous coronary intervention (PCI) is the preferred strategy [2]. The invasive management is also preferred in individuals with non-ST elevation MI. Meanwhile, age appears one of the most important predictors of clinical outcomes and potentially can strongly influence the management of MI [3]. Because of the high incident rate of MI and its potential adverse clinical outcomes and high complications rate, especially in the elderly, characterising of well-established risk factors and identifying new ones seems to be an important goal that could contribute to the reduction of mortality rates [4]. The evidence for the independent influence of the patient's sex and advanced age on the management and prognosis of patients with MI is unclear [5, 6]. Although both age and sex are associated with high costs of management of patients hospitalized for MI, sex, but not age occurred to be independently related to the cost of management [7, 8].

The advanced age defines individuals aged over 80 years (according to the American Geriatric Society and the World Health Organization) or individuals aged over 85 years also called the oldest old (according to BGS - the British Geriatrics Society) [9, 10]. However, authors of some recent publications proposed a higher cut-off for the oldest old as 90 years [11, 12]. The medical care of this growing population has become a topic of interest and remains a challenge for practitioners and healthcare organizations. In recent decades, studies focused on cohorts describing the population of the oldest old were carried out, among others the Vitality

90+ study, the Leiden 85-plus study or the Newcastle 85+ study [13]. However, the management and predictors of MI outcomes with advanced age remain an issue of debate [14]. For these reasons, we carried out research focused on nonagenarians hospitalized for MI to better understand this population's characteristics and describe factors that should be considered when planning healthcare for the oldest old individuals.

This study aimed to characterize management and variables related to event-free survival in patients with acute MI aged at least 90.

MATERIAL AND METHODS

We included all patients aged at least 90 years hospitalized and diagnosed with acute MI in Poland between 2014 and 2020 and reported to the National Health Fund (NHF) claims data. Hospitalization was defined as admission to a healthcare facility lasting >24 hours excepting patients died within 24 hours, who was also included. The index hospitalization for MI was described as a continuous hospital stay, including all possible transfers between wards or hospitals for any reason until a patient's discharge home or death. If the time delay between hospital discharge and the subsequent admission for MI was ≤1 day, both admissions were considered due to the same MI. We classified hospitalization for MI according to ICD-10 codes I21 or I22 as the primary diagnosis at any hospital ward. Invasive management was defined as performing coronary angiography, while invasive treatment as PCI or coronary artery bypass grafting.

A patient's history was determined using the NHF claims data. A patient was coded as having a disease (e.g., diabetes or heart failure [HF]) if any hospital or outpatient clinic reported the condition to the NHF database. The data on the participation in the Management Care Programme for Acute MI Survivors was also based on the NHF claims data [15]. Survival was determined according to the national database of deaths. Recurrent hospitalizations, including hospitalizations for acute MI, stroke, and invasive cardiac procedures, were determined using the claims data.

Ethics committee approval was not needed as the authors analysed the national database. Informed consent was not required.

Endpoints

The primary endpoint was defined as death from any cause. Secondary endpoints were defined as all-cause death or MI or stroke and all-cause death or hospitalization for any cardiovascular reason during the observation period of one year from the MI admission.

Statistical analysis

Continuous variables are presented as medians (interquartile range), while categorical values are presented as percentages as appropriate. The Shapiro–Wilk test was used to assess the normality. Normally distributed continuous variables were compared using Student's t-test. The Mann–Whitney U test was used for variables without normal distribution. The χ^2 test was applied to all categorical variables. A *P*-value of less than 0.05 was considered statistically significant. Multivariable, stepwise logistic analysis assessed factors independently related to the in-hospital mortality. Kaplan–Meier methods were used to construct unadjusted survival curves for each outcome. The survival was compared using the log-rank test. Cox proportional hazard regression analysis was used to assess the independent predictors of the endpoints. Beginning with all the variables presented in Table 1, stepwise analysis was conducted using the probability value <0.05. The statistics were calculated with STATISTICA 13 software (TIBCO Software, Palo Alto, CA, US).

RESULTS

A total of 14970 patients (median age 92.7 [90.9–93.8]) were hospitalized for acute MI from 2014 to 2020 year in Poland, including 4666 men (median age 92.5 [90.8–93.6]) and 10 304 women (median age 92.7 [91.0–93.9]). The analysed group is presented in Table 1. We found significant sex-based differences in respect of a number of comorbidities: hypertension and diabetes were more prevalent in females, while HF, atrial fibrillation (AF), chronic kidney disease, chronic obstructive pulmonary disease (COPD), history of coronary artery disease and the history of neoplasms were found in men more often. Hypertension was the most prevalent disease both in females and males. Overall, 67 % of patients were hospitalized in the cardiology department. Invasive management was introduced in 47% of patients, including percutaneous coronary intervention (PCI) and coronary artery bypass grafting.

The median duration of hospitalization was 7.0 (4.0–11.0) days (8.0 [5.0–11.0] days when patients died during the index hospitalization were excluded). In-hospital mortality was 27.8% (25.1% in men and 29.0% in female patients; *P* <0.001), 23.0% in patients managed invasively and 32.1% in those managed conservatively (*P* <0.001). The sex-based difference in the risk of death was significant in patients managed invasively (19.9% in men vs. 24.7% in women; *P* <0.001) but not among those managed non-invasively (31.6% vs. 32.4%; *P* = 0.50). The variables independently related to the risk of in-hospital death were age, sex, invasive management, stroke, history of MI or PCI, and hospitalization in a department of cardiology (Table 2).

Overall, 198 (3.1 %) patients, including 93 men (4.5%) and 105 women (2.5%; P <0.001) took part in the Management Care Programme for Acute MI Survivors following discharge. We noted significant difference in the proportion of MI survivors participating in the managed care programme from 2017 to 2020 (0.7% in 2017, 2.9% in 2018, 4.1% in 2019, and 5.1% in 2020; P <0.001).

The one-year all-cause mortality following discharge was 38.1% (females: 38.4%, males: 37.5%; P = 0.27), the endpoint consisting of all-cause death, MI, or stroke within one year following discharge occurred in 42.6% of patients (females: 42.8%, males: 42.2%; P = 0.44), while the endpoint consisting of all-cause death or cardiovascular hospitalization within one year following discharge occurred in 59.0% (females: 58.2%, males: 60.7%; P = 0.046) (Figure 1). Variables independently related to the probability of event-free survival following discharge are presented in Table 3. Age, HF, AF, hypertension, diabetes, COPD, invasive management of MI, and hospitalization in a department of cardiology were independently related to the all-cause death risk.

Finally, we analysed the risk of death from admission to the hospital to the 12th month following discharge. The one-year all-cause mortality (in-hospital and post-discharge deaths combined) was 54.3% (females: 56.3%, males: 53.2%, P<0.001). Table 4 presents independent variables of one-year mortality: age, HF, diabetes, hypertension, COPD, invasive management of MI, hospitalization in a department of cardiology or internal medicine, but not sex was independently related to the risk of death.

DISCUSSION

Despite a huge advance in the knowledge concerning cardiovascular diseases, management of MI in the long-life patients represents a clinical challenge. The demographic structure of the studied group is representative for the population of the oldest old patients and underscore the role of the gender gap in the longevity [5]. The long-lived male population remains more selected, and they usually present better general health status [16]. Meanwhile, nonagenarian men in our study suffered more often from previous cardiovascular events, AF, HF and chronic kidney disease, and PCI was performed more frequently than females. Similar observations, concerning multimorbidity and the clinical profile of the oldest old, were highlighted in other studies [17, 18].

Our study highlighted that male sex was independently related to the post-discharge mortality and in patients managed invasively as indicated by the multivariable analysis. Consequently, sex was not an independent predictor of survival when in-hospital and post-discharge deaths were combined. Moreover, in our study variables independently related to the higher risk of post-discharge death were not only age but also HF, AF, diabetes, and COPD, which was also associated with the length of hospitalisation. It is well established that individual comorbidities are common and can be associated with adverse outcomes in patients with cardiovascular disease [19]. However, future cardiovascular guidelines should address common comorbidity index to assess its impact on medical care including tailored, individualised treatment in the oldest olds [20].

The mean age as well as the median age of the analyzed group were slightly over 92 years. The research on longevity highlighted that rapid functional physical decline occurs from age 80 to age 90 [21, 22]. These data were observed in studies concerning longevity as well as the aging process in the oldest old such as the Polish Centenarian Programme POLSTU, or and U.S. centenarians' study [23, 24]. Age remains a factor strongly contributing to both in-hospital and post-hospital death risk [25, 26].

Our data showed that hospitalisation in a cardiology department is associated with reduced length of hospitalisation of patients with MI and with improved survival. It could be potentially related to better management of patients hospitalized in cardiology departments and simultaneously underdiagnosis of patients with atypical symptoms of MI such as falls, delirium or functional decline in the other departments [27]. This could be also potentially related to the higher number of comorbidities in patients hospitalized in other than cardiology departments [28].

The launched in 2017 the MAnaged Care for Acute MI Survivors (MACAMIS) system, comprising a continuum of acute treatment of MI, staged revascularization, cardiac rehabilitation, cardiac electrotherapy, and cardiac ambulatory care within one year following MI, has been accompanied by increased access to early cardiac rehabilitation, cardiac consultations, and a lower risk of death and cardiovascular events [15]. The present data suggests that managed care following MI may also benefit the nonagenarian population. However, a selection bias towards healthier subjects may be particularly strong in this age group considering this analysis is observational [29].

Significantly, invasive management was related to a lower risk of in-hospital death and a higher probability of event-free survival following discharge. In addition, PCI is associated with shorter hospital stays. On the other hand, we noted a higher in-hospital mortality among patients undergoing PCI. However, it was not possible to analyse patients with MI with and without ST-elevation separately, as the claims data in Poland, based on the 10th International Classification of Diseases, do not contain such information. A recently published Japanese study has investigated 1-year all-cause and cardiovascular (CV) mortality, and major adverse cardiovascular events (MACE; cardiovascular death, MI, and stroke) of oldest-old patients who underwent PCI compared with the other older patients, using a nationwide registration system. Authors highlighted that despite advances in medical sciences, nonagenarians who have undergone PCI still face a considerably increased risk for major adverse cardiovascular events and major bleeding. Moreover, adverse outcomes occurred 1.5 times more frequently in nonagenarians than in octogenarians [30].

According to our data diabetes, renal failure, and COPD remain significant determinants of mortality in the oldest olds hospitalized for MI. On the other hand, the diagnosis of hypertension was associated with a lower mortality rate. In some cases, the lack of diagnosis of hypertension might probably be a marker of pure functional status, HF, and other severe comorbidities [31]. Indeed, functional decline could better predict adverse outcomes than chronic diseases [32].

Undoubtedly, other factors (such as functional decline, social situation, frailty syndrome or malnutrition) could also influence the clinical outcomes in long-lived patients with MI. Indeed, malnutrition was associated with high all-cause mortality, regardless of clinical variables, coronary revascularization, and optimal medical treatment [33, 34]. Moreover, the care and outcomes of acute and chronic cardiovascular disease management are impacted by geriatric syndromes such as frailty syndrome and the general health status of an individual at baseline [35, 36].

The present analysis has several limitations. Firstly, this is an observational cohort study. Hence, only a statistical association rather than any causal relationships could be confirmed. Secondly, we could not analyse patients' lifestyles or the prescription rates for cardioprotective drugs. Thirdly, we could not analyse data concerning geriatric syndromes (such as dementia or frailty syndrome and functional decline). Including such data in the present analysis could have increased the impact of our results. Fourthly, we could not analyse patients with MI with and without ST-elevation separately, as the claims data in Poland do not contain such information. Moreover, the current results are based on the robustness of the public databases we used. On the other hand, a major advantage of the present study is the analysis of an extensive, nationwide database covering virtually all patients hospitalized for MI between

2014 and 2020 in Poland. Thus, the data regarding therapy, readmissions, and deaths summarises everyday clinical practice and its outcomes in the oldest olds.

CONCLUSIONS

Variables independently related to the higher risk of post-discharge death were age, HF, AF, diabetes, and COPD. When managed invasively, males at least 90 years hospitalized for MI, have lower in-hospital, but higher post-discharge mortality than females. Sex is not an independent predictor of mortality nor morbidity in patients managed conservatively. Invasive management was associated with lower risk of mortality and major adverse events. Further studies are needed to precisely describe the correlation between comorbidities, ageing processes, and other factors influencing clinical outcomes of myocardial infraction in long-lived patients.

Article information

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Table 1. Characteristics of the analyzed group

Variable	Total n = 14 970	Men n = 4666	Women n = 10 304	*P*-value
Age, median (IQR)	92.7 (90.9–93.8)	92.5 (90.8–93.6)	92.7 (91.0–93.9)	<0.001
Hypertension, n (%)	11697 (78.1)	3528 (75.6)	8169 (79.3)	<0.001
Heart failure, n (%)	6970 (46.7)	2241(48.0)	4729 (45.9)	0.02
Atrial fibrillation, n (%)	3125 (20.9)	1073 (23.0)	2052 (19.9)	<0.001
Diabetes, n (%)	3834 (25.6)	1121 (24.0)	2713 (26.3)	0.003
Chronic kidney disease, n (%)	2200 (14.7)	849 (18.2)	1351 (13.1)	<0.001
History of dialysis, n (%)	48 (0.3)	24 (0.5)	24 (0.2)	0.005
History of MI, n (%)	1610 (10.8)	569 (12.2)	1041 (10.1)	<0.001
History of PCI, n (%)	1009 (6.7)	422 (9.0)	587 (5.7)	<0.001
History of CABG, n (%)	10 (0.1)	6 (0.1)	4 (0.04)	0.05
History of stroke				
Ischemic, n (%)	490 (3.3)	136 (2.9)	354 (3.4)	0.01
Hemorrhagic, n (%)	22 (0.1)	10 (0.2)	12 (0.1)	0.15
Chronic obstructive pulmonary disease, n (%)	1359 (9.1)	645 (13.8)	714 (6.9)	<0.001
History of neoplasm, n (%)	2550 (17.0)	1245 (26.7)	1305 (12.7)	<0.001
Index hospitalization				
Coronary angiography, n (%)	7032 (47.0)	2565 (55.0)	4467 (43.4)	<0.001

PCI, n (%)	5956 (39.8)	2178 (46.7)	3778 (36.7)	<0.001
CABG, n (%)	24 (0.2)	15 (0.3)	9 (0.1)	<0.001
Hospitalization in a department of				
Cardiology, n (%)	9982 (66.7)	3280 (70.3)	6702 (65.0)	<0.001
Internal medicine, n (%)	4049 (27.0)	1094 (23.4)	2955 (28.7)	<0.001
Other, n (%)	935 (6.2)	291 (6.2)	644 (6.3)	0.97
Participation in the Managed Care Programme following hospitalisation, n (%)[a]	198 (3.1)	93 (4.5)	105 (2.5)	<0.001

[a]Only in those who were hospitalized from 2017 to 2020 and did not die during the index hospitalization (n = 6330)

Abbreviations: CABG, coronary artery bypass grafting; MI, myocardial infarction; PCI, percutaneous coronary intervention

Table 2. Variables independently related to the in-hospital death (n = 14 970). The table presents the results of multivariable logistic analysis

Variable	All patients n =14 970	Patients managed invasively n =7032	Patients managed non-invasively n =7938
	Odds ratio (95% confidence intervals)		
Age, per 1 year	1.06 (1.04–1.08)	1.09 (1.06–1.12)	1.05 (1.03–1.07)
Sex			
Females	1.00	1.00	–
Males	0.88 (0.81–0.95)	0.79 (0.70–0.90)	
Hypertension	0.81 (0.74–0.88)	0.74 (0.64–0.85)	0.83 (0.74–0.93)
Heart failure	–	1.18 (1.05–1.32)	–
Diabetes	–	–	1.14 (1.20–1.28)
History of MI	0.75 (0.65–0.88)	–	0.69 (0.57–0.83)
History of PCI	0.60 (0.49–0.75)	0.42 (0.32–0.55)	0.73 (0.55–0.97)
History of stroke	1.22 (1.01–1.47)	–	1.22 (1.01–1.47)
Chronic obstructive pulmonary disease	–	–	1.20 (1.02–1.32)

History of neoplasm	–	0.79 (0.67–0.92)	–
Invasive management	0.71 (0.66–0.77)	–	–
PCI during hospitalisation	–	1.23 (1.05–1.44)	–
Hospitalization in a department of			
Cardiology	0.64 (0.56–0.74)	0.60 (0.47–0.78)	0.64 (0.54–0.76)
Internal medicine	0.74 (0.63–0.85)	0.44 (0.32–0.61)	0.81 (0.68–0.96)
Other	1.00	1.00	1.00

Abbreviations: see Table 1

Table 3. Results of multivariable analysis: variables independently related to the risk of cardiovascular events in the post discharge period (n = 10 804)

Variable	All-cause death	All-cause death or MI or stroke	All-cause death or hospitalization for cardiovascular reasons
	Hazard ratio (95% confidence intervals)		
All patients n = 10 804			
Age, per 1 year	1.06 (1.05–1.08)	1.05 (1.04–1.07)	1.03 (1.02–1.05)
Sex			
Females	–	–	1.00
Males			1.09 (1.03–1.15)
Hypertension	0.88 (0.81–0.95)	0.89 (0.83–0.97)	0.92 (0.87–0.99)
Heart failure	1.14 (1.07–1.22)	1.12 (1.50–1.20)	1.17 (1.11–1.24)
Atrial fibrillation	1.10 (1.02–1.17)	1.09 (1.01–1.17)	1.13 (1.06–1.20)

Diabetes	1.11 (1.04–1.20)	1.10 (1.03–1.18)	1.12 (1.06–1.19)
Chronic kidney disease	–	–	1.11 (1.04–1.19)
History of MI	–	1.12 (1.02–1.22)	1.13 (1.05–1.22)
History of PCI	0.85 (0.74–0.95)	–	–
Chronic obstructive pulmonary disease	1.15 (1.03–1.27)	1.13 (1.03–1.25)	1.12 (1.03–1.21)
Invasive management	0.55 (0.51–0.59)	0.59 (0.55–0.63)	0.79 (0.75–0.84)
Hospitalization in a department of cardiology*	0.85 (0.79–0.91)	0.87 (0.81–0.93)	0.90 (0.85–0.96)
Participation in the Managed Care Programme	–	–	0.78 (0.63–0.98)
Patients managed invasively n = 5418			
Age per 1 year	1.10 (1.07–1.12)	1.08 (1.05–1.10)	1.04 (1.03–1.06)
Sex Females Males	 1.00 1.14 (1.03–1.27)	 1.00 1.13 (1.03–1.25)	 1.00 1.16 (1.07–1.25)
Heart failure	1.20 (1.07–1.34)	1.17 (1.06–1.29)	1.19 (1.09–1.28)
Atrial fibrillation	1.17(1.03–1.32)	1.14 (1.02–1.28)	1.18 (1.07–1.29)
Diabetes	–	1.11 (1.00–1.24)	1.13 (1.05–1.21)
History of chronic kidney disease	1.18 (1.02–1.36)	–	1.18 (1.06–1.31)
Chronic obstructive pulmonary disease	1.25 (1.06–1.46)	1.23 (1.06–1.43)	1.13 (1.00–1.28)
History of MI	–	–	1.15 (1.03–1.29)
History of PCI	0.82 (0.68–0.98)	–	–
History of neoplasm	–	–	0.91 (0.82–1.00)

PCI during hospitalisation	0.81 (0.71–0.92)	0.83 (0.74–0.93)	–
Hospitalization in a department of cardiology*	–	–	0.90 (0.81–0.98)
Participation in the Managed Care Programme	–	–	0.79 (0.63–0.98)
Patients managed non-invasively n = 5386			
Age per 1 year	1.05 (1.03–1.06)	1.04 (1.03–1.06)	1.03 (1.01–1.04)
Hypertension	0.86 (0.78–0.95)	0.89 (0.81–0.97)	0.92 (0.84–1.00)
Heart failure	1.10 (1.02–1.20)	1.11 (1.02–1.20)	1.17 (1.09–1.26)
Atrial fibrillation	–	–	1.10 (1.01–1.19)
Diabetes	1.11 (1.01–1.21)	1.10 (1.01–1.20)	1.12 (1.03–1.21)
History of MI	–	1.23 (1.08–1.40)	1.12 (1.01–1.24)
History of PCI	–	0.78 (0.64–0.94)	
Hospitalization in a department of cardiology[a]	0.84 (0.78–0.91)	0.88 (0.81–0.94)	0.91 (0.85–0.97)

[a]Department of hospitalisation of patients diagnosed with acute MI

Abbreviations: see Table 1

Table 4. Results of multivariable analysis: variables independently related to the one–year mortality (in–hospital and post–discharge deaths combined)

Variable	Hazard ratio (95% confidence intervals)
Age per 1 year	1.05 (1.04–1.06)
Hypertension	0.87 (0.82–0.92)
Heart failure	1.09 (1.04–1.14)
Diabetes	1.08 (1.02–1.13)

History of PCI	0.71 (0.64–0.79)
Invasive management	0.65 (0.62–0.69)
Chronic obstructive pulmonary disease	1.09 (1.01–1.18)
Hospitalization in a department of	
Cardiology	0.76 (0.70–0.83)
Internal medicine	0.85 (0.78–0.93)
Other	1.00