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ORIGINAL ARTICLE

Older-age-related one-year mortality in patients with acute myocardial infarction with ST elevation treated with percutaneous coronary angiography

Aleksandra Milosevic[1,2], Ivana Jankovic[1], Sofija Glisic[2], Zarko Ivanovic[3], Amin Mehmedovic[2], Lidija Savic-Spasic[1,2], Dragan Matic[1,2], Milika Asanin[1,2]

[1] Department of Cardiology, University Clinical Centre of Serbia, Belgrade, Serbia

[2] Belgrade University, Faculty of Medicine, Belgrade, Serbia

[3] Department of Pulmonology, University Clinical Centre of Serbia, Belgrade, Serbia

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Correspondence to:
Aleksandra Milosevic
Department of Cardiology, University Clinical Centre of Serbia,
2, Pasterova, 11000 Belgrade, Serbia
Email: milosevi@eunet.rs

Summary

Introduction: The rise in life expectancy has resulted in a greater prevalence of elderly patients presenting with acute myocardial infarction with ST elevation (STEMI).

The Aim: Investigating the association between advanced age and one-year mortality in STEMI patients treated with primary PCI.

Material: The study involved 395 STEMI patients who underwent primary PCI and were admitted to the Coronary Care Unit between June and December 2019. The patients were categorized into three age groups: ≤64 years, 65-74 years, and ≥75 years, with the ≤64-year age group as the comparison reference. All-cause mortality was analyzed over a one-year period.

Results: The mean age of the patients was 62 years; 27.6% were aged between 65 and 74, while 15.7% were 75 years or older. Women accounted for 28.7% of the total, with higher representation in older age groups. Older patients exhibited elevated rates of diabetes, chronic renal insufficiency, anemia, and heart failure (Killip 2-4). Primary PCI rates were notably high across all age groups at 93.3%, 93.6%, and 87.1%, respectively, primarily using a radial approach. The one-year mortality risk was twice as high for those aged 64 to 75 years and seven times higher for those aged 75 and over, with age 75 and above being an independent predictor of all-cause mortality.

Conclusion: Elderly patients with STEMI, particularly those aged 75 and older, show a significantly higher one-year mortality rate compared to their younger counterparts aged 64 and younger due to the considerable burden of comorbidities, even when receiving guideline-directed therapies.

Keywords: the elderly, STEMI, primary PCI, mortality

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INTRODUCTION

An increase in life expectancy has led to a growing number of elderly patients presenting with acute myocardial infarction with ST elevation (STEMI). Patients aged 75 years and older represent approximately 14–28% of all STEMI cases (1-3).

Diagnosing and managing STEMI in this population presents unique challenges that significantly influence mortality rates. The primary challenge involves an increased prevalence of atypical clinical presentations among older adults, which may delay prompt diagnosis and timely intervention (4). Furthermore, older patients often demonstrated a higher prevalence of coronary risk factors, including hypertension, diabetes mellitus, and chronic kidney disease (CKD), complicating both clinical assessment and therapeutic decision-making processes. Frailty also emerges as a significant concern in this age group (5) as it correlates with diminished physiological reserves, ultimately rendering these patients more susceptible to adverse outcomes during hospitalization (6). Finally, there is an elevated risk of in-hospital complications, including bleeding, contrast-induced nephropathy, and cardiogenic shock. All of this makes this population significantly associated with a high mortality rate.

The current standard of care for STEMI, which incorporates primary percutaneous coronary intervention (PCI) alongside dual antiplatelet therapy (DAPT), has significantly improved the outcomes for patients of all ages enrolled (7). These therapies reduce mortality, limit myocardial damage, and enhance long-term prognosis. However, older adults, particularly those aged 75 and over, are often underrepresented or excluded from numerous clinical trials (8, 9). In contrast, a limited number of studies involving elderly patients have demonstrated that PCI offers more benefits than fibrinolytic therapy (10-12) or medication therapy alone in terms of mortality in this age group (13-15). This has led to insufficient evidence concerning the effectiveness of PCI specific to this population, thereby complicating the formulation of optimal treatment strategies.

The aim is to explore the link between STEMI patients aged 65 and older and one-year mortality after primary PCI.

METHODS

Study design and patient population. This single-center observational study included 395 consecutive patients with ST-elevation myocardial infarction (STEMI) who were admitted to the Coronary Care Unit between June and December 2019 and referred for primary percutaneous coronary intervention (PCI). The patients were divided into three age groups for analysis: ≤64 years, 65–74 years, and ≥75 years, with the ≤64-year age group as the comparison reference.

The diagnosis of STEMI was established based on the Fourth Universal Definition of Myocardial Infarction (16). All patients received a loading dose of dual antiplatelet therapy, consisting of aspirin and either ticagrelor (180 mg), clopidogrel (600 mg), or prasugrel (60 mg), followed by maintenance doses of aspirin (100 mg daily) combined with either clopidogrel (75 mg daily), ticagrelor (90 mg twice daily), or prasugrel (10 mg daily). Anti-ischemic therapy was administered according to current guidelines and tailored to each patient's clinical status.

All patients included in the study underwent coronary angiography and PCI. The interventional strategy, including decisions regarding stenting, vascular access (via the radial or femoral artery), and the use of glycoprotein IIb/IIIa inhibitors during or after the intervention, was determined at the discretion of the interventional cardiologist. Transthoracic echocardiography was conducted within the first three days following PCI, and the left ventricular ejection fraction was classified as reduced if it fell below 40%.

Anemia was defined as the hemoglobin level below 12 g/dL in women and below 13 g/dL in men. Baseline kidney function was assessed using the Cockcroft-Gault equation, with an estimated glomerular filtration rate (eGFR) of <60 mL/min/m^2 considered indicative of reduced kidney function.

Data collection. Patient demographic information, including age, sex, and cardiovascular risk factors (hypertension, hyperlipidemia, diabetes mellitus, and smoking status), was collected. Medical histories, such as chronic kidney disease (CKD), anemia, and prior cardiovascular conditions (e.g., myocardial infarction, stroke, previous percutaneous revascularization, and vascular disease), were also documented. Furthermore, key laboratory parameters, angiographic findings, and procedural characteristics were recorded, including details of drug therapy prescribed at discharge. A one-year follow-up was conducted through telephone interviews or outpatient visits to gather data on clinical outcomes and patient status.

Outcomes. The primary endpoint was one-year all-cause mortality.

Ethics. This study has been conducted in accordance with all ethical principles of the Declaration of Helsinki and in accordance with and with approval from all national and institutional ethical standards.

Statistical analysis. The collected data were analyzed using standard descriptive and analytical statistical methods. Continuous variables were expressed as the mean ($\bar{x}$) ± standard deviation (SD) for normally distributed data and assessed using the Student's t-test. The median and interquartile range (IQR) were reported and compared for non-normally distributed data using the Mann-Whitney U test. Categorical variables were presented as absolute frequencies (n) and percentages, with comparisons

conducted using the chi-square test. Cumulative survival curves over a one-year follow-up period for the compared age groups were generated using the Kaplan-Meier method and analyzed with the Log-Rank test.

Univariable and multivariable analyses were performed using the Cox proportional hazards model, with patients aged ≤64 as the reference group to identify predictors of all-cause mortality. Statistical significance was determined using two-tailed p-values of < 0.05. All analyses were conducted with IBM SPSS Statistics version 21 (SPSS Inc., Chicago, IL, USA).

RESULTS

From June to December 2019, 404 STEMI patients were hospitalized, and 395 were referred for primary PCI, which led to their inclusion in the statistical analysis.

The baseline clinical characteristics are presented in **Table 1**. The average age of the patients was 62 years; 27.6% were between 65 and 74 years, while 15.7% were 75 years and older. Women represented 28.7% of the patient population and displayed progressively higher representation in the older age groups, with 35.8% in the 65-74 age group and 50% among individuals aged 75 years and above. Older patients exhibited a greater prevalence of conditions, including arterial hypertension, diabetes mellitus, chronic kidney disease, anemia, and prior cerebrovascular events, but a lower incidence of active smokers. Furthermore, patients aged 75 years and above had more frequent prior revascularization procedures, including PCI or CABG, compared to those aged 64 years and younger. Heart failure, classified as Killip class II-IV, was frequently observed in elderly patients, particularly those aged 65 to 74 years and those aged 75 years and older, as well as with a reduced ejection fraction (EF 40%). Older patients often presented with new-onset atrial fibrillation. Moreover, there was a significant difference in the medications prescribed upon hospital discharge; older patients more commonly received the less potent P2Y12 inhibitor clopidogrel and diuretics **(Table 1)**.

Regarding coronary angiograms and procedural characteristics, the findings indicated that multivessel disease was more prevalent among older patients, specifically those aged 65 to 74 and those aged 75 and older. Moreover, incomplete revascularization was more common among older patient groups. Additionally, in patients aged 75 and above, the presence of the left main artery or graft as an infarct artery was significantly more frequent compared to patients aged 65 years or younger. Neverthe-

Table 1. Baseline clinical characteristics and discharge therapy

Characteristics	≤ 64 yrs N= 224	65-74 yrs * N=109	≥75 yrs ** N=62	P*	P**
Female, n (%)	44 (19.6%)	39 (35.8%)	31 (50.0%)	**0.001**	**<0.001**
Hypertension n(%)	140 (62%)	77 (70.6%)	54 (87.1%)	0.157	**<0.001**
Diabetes mellitus n (%)	47(21.1%)	43 (39.4%)	23 (37.1%)	**<0.001**	**0.010**
HLP n (%)	136 (62.1%)	46 (43.0%)	24 (40.0)	**0.001**	**0.002**
Active smokers n (%)	136 (59.6%)	37 (34.3%)	1 (1.6%)	**<0.001**	**<0.001**
Previous MI n (%)	30 (13.5%)	23 (21.1%)	13 (21.0%)	0.074	0.144
Previous CVI n (%)	5 (2.2%)	9 (8.3%)	8 (12.9%)	**0.010**	**<0.001**
Previous PCI n (%)	28 (12.6%)	19 (17.4%)	15 (24.2%)	0.231	**0.024**
Previous CABGn (%)	5 (2.2%)	2(1.8%)	5 (8.1%)	0.808	**0.028**
CKD n (%)	22 (10.0%)	31(28.7%)	35 (56.6%)	**<0.001**	**<0.001**
Anemia n (%)	25 (11.2%)	34 (31.2%)	36 (58.1%)	**<0.001**	**<0.001**
Killip class 2-4 n (%)	42 (18.8%)	31 (28.7%)	24 (38.7%)	**0.040**	**0.001**
LVEF<40% n (%)	46 (21.8%)	38 (37.3%)	20 (35.7%)	**0.004**	**0.032**
New-onset AF n (%)	3 (1.3%)	9 (8.3%)	9 (14.5%)	**0.001**	**<0.001**
LDL cholesterol med (IQR)	3.10(2.54-3.79)	2.77(2.14-3.40)	2.38(1.81-3.28)	**0.001**	**<0.001**
Ticagrelor n (%)	155 (73.5%)	65 (65.7%)	18 (40.9%)	0.064	**<0.001**
Prasugrel n (%)	11 (5.2%)	2 (2.0%)	1 (2.3%)		
Clopidogrel n (%)	45 (21.3%)	32 (32.3%)	25 (56.8%)		
Beta-blocker n (%)	183 (86.3%)	88 (88.9%)	39 (83.0%)	0.529	0.554
ACE inhibitor n (%)	161 (75.9%)	71 (71.7%)	37 (78.7%)	0.425	0.684
Statin n (%)	204 (96.2%)	96 (97.0%)	42 (89.4%)	0.741	0.051
Diuretic n (%)	55 (26.1%)	47(47.5%)	24 (51.1%)	**<0.001**	**0.001**

DM: Diabetes mellitus; IM: myocardial infarction; CVI: Cerebrovascular insult; PCI: percutaneous coronary intervention; CABG: coronary artery bypass graft; HKD: Chronic kidney disease, ACE-angiotensin-converting enzyme *Comparison between ≤ 64 yrs and 65-74 yrs; ** Comparison between 65-74 yrs and ≥75 yrs

Table 2. Baseline angiographic and procedural characteristics

Characteristics	≤ 64 yrs N=224	65-74 yrs * N=109	≥75 yrs ** N=62	P*	P**
pPCI n (%)	209 (93.3%)	102 (93.6%)	54 (87.1%)	0.925	0.112
Stent implanted n (%)	202 (90.6%)	98 (90.7%)	49 (80.3%)	0.963	0.027
Radial approach n (%)	199 (89.2%)	97 (89.0%)	52 (83.9%)	0.946	0.249
GpIIb/IIIa n (%)	19 (8.5%)	15 (13.8%)	8 (12.9%)	0.135	0.292
One-vessel disease n (%)	111 (49.6%)	36 (33.0%)	16 (25.8%)	**0.004**	**0.001**
Complete revascularization n (%)	127 (58.3%)	51 (47.2%)	21 (34.4%)	0.060	**0.001**
LAD n (%)	105 (47.7%)	44 (40.4%)	18 (29.5%)		
LCx n (%)	33 (15.0%)	13 (11.9%)	8 (13.1%)		
RCA n (%)	76 (34.5%)	50 (45.9%)	28 (45.9%)	0.206	0.006
LM n (%)	2 (0.9%)	0 (0.0%)	4 (6.6%)		
graft n (%)	4 (1.8%)	1 (0.9%)	3 (4.9%)		

LAD-left anterior artery, LCx-left circumflex artery, LM-left main artery, RCA-right coronary artery, *Comparison between ≤ 64 yrs and 65-74 yrs; ** Comparison between 65-74 yrs and ≥75 yrs

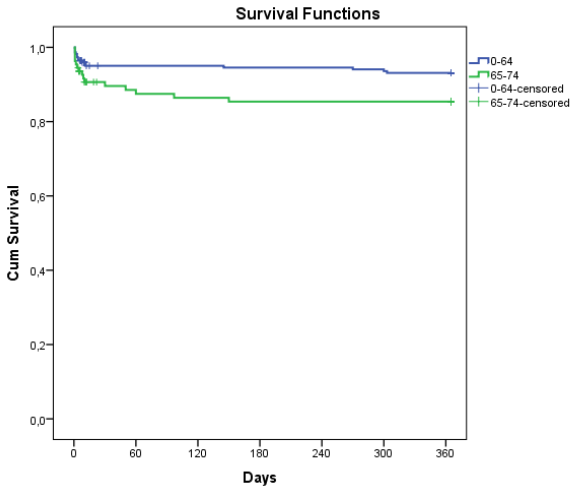
Table 3. All-cause mortality on 30-day and 1-year

	≤ 64 yrs N=224	65-74 yrs * N=109	≥75 yrs ** N=62	P*	P**
30 days n(%)	11 (4.9%)	11 (10.1%)	17 (27.4%)	0.074	**<0.001**
1 year n (%)	15 (6.7%)	15 (13.8%)	24 (38.7%)	**0.035**	**<0.001**

less, primary PCI was performed at a high rate across all three age groups, with rates of 93.3%, 93.6%, and 87.1%, predominantly using a radial approach. Stent implantation was performed at high rates across all age groups, although significantly less in patients aged 75 and older, with no notable differences observed in the use of Gp IIb/IIIa inhibitors among the different age groups **(Table 2)**.

Table 3 presents the one-year and 30-day all-cause mortality rates. At the one-year follow-up, mortality was recorded in 55 patients, accounting for 13.6% of the total, while the 30-day mortality rate was noted in 39 patients, which is 9.9%. It was observed that patients aged 75 years and older had significantly higher mortality rates at both the 30-day and one-year marks compared to those aged 64 and younger.

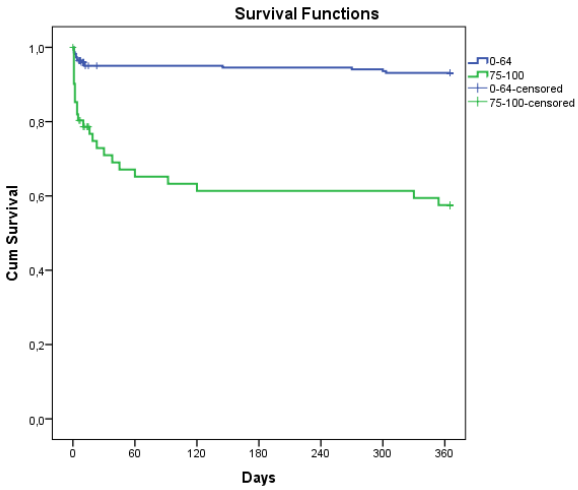
Kaplan-Meier curves illustrate one-year survival rates for patients aged 65–74 **(Figure 1)** and those aged 75 and older (Figure 2). Both age groups showed statistically significantly lower one-year survival compared to patients 64 and younger, as determined by log-rank tests ($p = 0.027$ and $p < 0.001$, respectively).



Log Rank – 0.027

No ≤ 64 yrs	224	213	213	212	211	220	199
No 65-75 yrs	109	96	95	94	94	94	94

Figure 1. Kaplan-Meier curves showing one-year survival rate in patients 64-75 years



Log Rank <0.001

No ≤ 64 yrs	224	213	213	212	211	220	199
No ≥75 yrs	62	42	40	40	40	40	38

Figure 2. Kaplan-Meier curves showing the one-year survival rate in patients 75 years and older

Table 4. Predictor of all-cause mortality at 30 days and 1 year

	Univariable Analysis		Multivariable Analysis	
	HR (95%CI)	p value	HR (95%CI)	p Value
		30 days		
65-74 yrs	2.16(0.93-4.99)	0.070	1.39(0.55-3.53)	0.484
≥75 yrs	6.41 (3.00-13.70)	**0.000**	3.35 (1.28-8.77)	**0.013**
DM	2.13 (1.12-4.03)	**0.021**	1.06 (0.52-2.15)	**0.872**
CKD	4.53 (2.41-8.51)	**<0.001**	2.00 (0.93-4.30)	**0.076**
Killip 2-4	2.62 (1.38-4.98)	**0.003**	1.81 (0.91-3.59)	**0.091**
Complete revascularization	0.14 (0.05-0.35)	**<0.001**	0.16 (0.06-0.46)	**0.001**
		1 year		
65-74 yrs	2.19 (1.07-4.48)	0.032	1.45 (0.64-3.13)	0.37
≥75 yrs	7.36 (3.85-14.07)	**0.000**	4.57 (2.05-10.18)	**0.000**
DM	**2.23 (1.30-3.82)**	**0.004**	1.10 (0.60-2.00)	**0.764**
CKD	**3.38 (2.24-6.54)**	**<0.001**	1.63 (0.86-3.10)	**0.137**
Killip 2-4	**3.32 (1.94-5.69)**	**<0.001**	2.43 (1.36-4.32)	**0.003**
Complete revascularization	**0.22 (0.11-0.44)**	**<0.001**	0.30 (0.15-0.61)	**0.001**

DM-Diabetes mellitus, CKD -Chronic kidney disease

Univariate Cox proportional hazards analysis showed that older patients, particularly those aged 65–74 and ≥75 years, had higher one-year mortality rates compared to patients aged ≤64. However, after adjusting for confounding factors including gender, diabetes mellitus, chronic kidney disease, Killip class II–IV, and incomplete revascularization, age ≥75 remained an independent predictor of all-cause mortality at both 30 days and one year **(Table 4)**.

DISCUSSION

The results of this observational study indicate that STEMI patients aged 75 and older, as well as those aged 65 to 74 who undergo primary PCI, have significantly higher one-year and 30-day mortality rates compared to individuals aged 64 and younger. Furthermore, the one-year mortality risk doubles for those aged 65 to 74 and increases sevenfold for those aged 75 and older. Additionally, being 75 or older is recognized as an independent prognostic factor for one-year mortality.

Our patients' demographic and baseline characteristics align with data from the literature, showing that the percentage of individuals aged 75 years and older with STEMI treated with primary PCI is comparable to that observed in our study, at approximately 18%. (3, 17, 18).

While the increased adoption of the recommended management strategies for treating STEMI (such as invasive therapy, DAPT) has significantly reduced the mortality rate among older patients over the past 15 years (19), even in the cases of cardiogenic shock (14), the mortality rate remains significantly higher compared to their younger counterparts. Topaz et al. demonstrated that among STEMI patients undergoing primary PCI from the TAPAS registry, those aged 75 years and older had both short- and long-term mortality rates more than four times higher than those under 75 years (17). Analysis of 5745 STEMI patients undergoing primary PCI from the APEX-AMI trial revealed that patients 65 years and older had an increased 90-day mortality rate (2.3% vs. 4.8% vs. 13.1%; >65 vs. 65-74 vs. ≤75 years, respectively). Furthermore, with every decade increase in age, there was a two-fold increase in the hazard of 90-day mortality (3). Results from the ULTIMASTER registry indicate that among STEMI patients treated with PCI using the Ultimaster stent, those aged ≥ 80 years (7.2%) experienced significantly higher one-year all-cause mortality compared to the younger group (10.1% vs 2.3%) (20).

The increased mortality rate associated with advancing age in STEMI patients, even when managed according to current guideline recommendations, may be attributed to the specific clinical profile of these individuals.

Firstly, patients aged 65 and over often have numerous comorbidities, particularly hypertension, diabetes mellitus, chronic kidney disease, and anemia. Each of these, both individually and synergistically, significantly affects the mortality rate, regardless of treatment with (21-23). Secondly, the proportion of women with acute coronary disease increased with advancing age. In our study, approximately 50% of patients aged 75 and older are female, consistent with observations from existing clinical research (3, 17). It is important to note that during menopause, there is a substantial increase in the incidence of cardiovascular disease among women (24) due to the decline of the protective effect of circulating on the endothelium of blood vessels (25). Additionally, it's well-documented that women tend to experience higher mortality rates than men following STEMI, both

during hospital stays and at the one-year mark after PCI (26). Thirdly, in our study, older patients experienced more frequent symptoms and signs of heart failure, as well as atrial fibrillation, conditions that are closely associated with an adverse prognosis (27, 28). Fourthly, as our study observed, the literary data confirmed that patients aged 65 and above exhibited significantly higher rates of multivessel coronary disease, leading to incomplete revascularization and subsequently contributing to poorer outcomes (27). In contrast, primary PCI was extensively performed across all age groups, predominantly using a radial approach. The administration of GpIIb/IIIa inhibitors was consistent across age groups, suggesting uniform treatment protocols despite variations in patient age and complexity. As a result, the older patients in our study received treatment that adhered to contemporary standards, akin to that of their younger counterparts.

Clinical status variations have led to significant differences in medical therapy among age groups at hospital discharge. Specifically, patients aged 75 years and older were prescribed more potent P2Y12 inhibitors less frequently, consistent with their safety profiles, particularly given the higher incidence of chronic kidney disease and anemia in this demographic. Moreover, diuretics were more commonly prescribed to older patients, especially those aged 75 and older, due to the frequent presence of reduced ejection fraction (EF) in this age group.

CONCLUSION

In recent years, the number of STEMI patients aged 75 and older has been increasing, along with a greater burden of comorbidities that significantly impact mortality rates. Although these older patients receive optimal invasive and pharmacological treatments, they do not benefit from standard treatment protocols to the same degree as younger populations. This complexity highlights the necessity for tailored approaches when managing acute coronary events in elderly patients to address their specific clinical and individual needs effectively.

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Author Contributions:

The conception or design of the work: A. M, M. A.

The acquisition, analysis or interpretation of data: L. S, I. J, S. G, Ž. I, A. M.

Preparing the draft of the manuscript: A. M, D. M.

Ethical Approval: This study has been conducted in accordance with all ethical principles of the Declaration of Helsinki and in accordance with and with approval from all national and institutional ethical standards.

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POVEZANOST STARIJEG ŽIVOTNOG DOBA SA JEDNOGODIŠNJIM MORTALITETOM KOD BOLESNIKA SA AKUTNIM INFARKTOM MIOKARDA SA ST ELEVACIJOM LEČENIH PRIMARNOM PERKUTANOM KORONARNOM INTERVENCIJOM

Aleksandra Milošević[1,2], Ivana Janković[1], Sofija Glišić[2], Žarko Ivanović[3], Amin Mehmedović[2], Lidija Savić-Spasić[1,2], Dragan Matić[1,2], Milika Ašanin[1,2]

Sažetak

Uvod: Povećanje očekivane dužine životnog veka je rezultiralo većom prevalencom bolesnika s akutnim infarktom miokarda sa ST elevacijom (STEMI).

Cilj: Ispitivanje veze između starije životne dobi i jednogodišnjeg mortaliteta kod bolensika sa STEMI lečenih primarnom PCI.

Metodologija: Studija je obuhvatila 395 bolesnika sa STEMI lečenih primarnom PCI u Koronarnoj jedinici u periodu jun-decembar 2019. godine. Bolesnici su kategorisani u tri starosne grupe : ≤ 64godine, 65-74 godina i ≥75 god, pri ćemu grupa ≤ 64godine služi kao referentna grupa za poređenje.

Rezultati: Prosečna starost pacijenata uključenih u studiju je bila 62 godine; 27,6% je bilo starosne dobi od 65 do 74 godine, dok je 15,7% imalo 75 godina ili više. Žene su činile 28,7% od ukupnog broja, sa većom zastupljenošću u starijim starosnim grupama. Pacijenti starosti od 65 do 74 godine i oni stariji od 75 godina su pokazali povećanu stopu dijabetesa, hronične bubrežne insuficijencije, anemije i srčane insuficijencije (Killip 2-4). Primena primarne PCI je bila značajno visoka u svim starosnim grupama i iznosila je 93,3%, 93,6% i 87,1%, izvedena je uglavnom radijalnim pristupom. Rizik od jednogodišnjeg mortaliteta bio je dvostruko veći za one od 64 do 75 godina i čak sedam puta veći za bolesnike od 75 i više godina, pri čemu je starost od 75 godina i više bila nezavisni prediktor ukupnog mortaliteta.

Zaključak: Stariji pacijenti sa STEMI, posebno oni od 75 godine i stariji, imaju znatno veću jednogodišnju stopu mortaliteta u poređenju sa onima od 64 godine i mlađim zbog značajnog opterećenja komorbiditetima uprkos primeni smernicama preporučenoj terapiji.

Ključne reči: starije osobe, STEMI, primarni PCI, mortalitet

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