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Comparison of Prognosis According to the Use of Emergency Medical Services in Patients with ST-Segment Elevation Myocardial Infarction

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Purpose: This study aimed to compare long-term clinical outcomes according to the use of emergency medical services (EMS) in patients with ST-segment elevation myocardial infarction (STEMI) who arrived at the hospital within 12 hr of symptom onset.
Materials and Methods: A total of 13104 patients with acute myocardial infarction were enrolled in the Korea Acute Myocardial Infarction Registry–National Institutes of Health from October 2011 to December 2015. Of them, 2416 patients with STEMI who arrived at the hospital within 12 hr were divided into two groups: 987 patients in the EMS group and 1429 in the non-EMS group. Propensity score matching (PSM) was performed to reduce bias from confounding variables. After PSM, 796 patients in the EMS group and 796 patients in the non-EMS group were analyzed. The clinical outcomes during 3 years of clinical follow-up were compared between the two groups according to the use of EMS.
Results: The symptom-to-door time was significantly shorter in the EMS group than in the non-EMS group. The EMS group had more patients with high Killip class compared to the non-EMS group. The rates of all-cause death and major adverse cardiac events (MACE) were not significantly different between the two groups. After PSM, the rate of all-cause death and MACE were still not significantly different between the EMS and non-EMS groups. The predictors of mortality were high Killip class, renal dysfunction, old age, long door-to-balloon time, long symptom-to-door time, and heart failure.
Conclusion: EMS utilization was more frequent in high-risk patients. The use of EMS shortened the symptom-to-door time, but did not improve the prognosis in this cohort.

Key Words: Emergency medical services, ST-segment elevation myocardial infarction, prognosis

INTRODUCTION

Despite the improvements in residential environments and nutritional conditions, advances in treatment methods, and economic growth, the death rate from chronic diseases is steadily increasing due to the growing aging population and lifestyle changes.[1] As of 2019, 117.4 per 100000 people die of cardiovascular diseases in Korea, with 60.4 per 100000 people dying of heart diseases, ranking second among all causes of death. In particular, heart disease-associated mortality has continued to increase over the last decade.[2] Moreover, acute myocardial infarction (AMI) is associated with a mortality rate of 30%, with 50% of deaths occurring before hospital arrival. An additional 5%–10% of survivors die and approximately 50% are re-hospitalized for AMI within a year.[3] The outcome of patients with ST-segment elevation myocardial infarction (STEMI), a representative heart disease, is determined by how quickly the coronary artery is reperfused after the appearance of symptoms.[4,5] Therefore, it is important for patients to recognize their symptoms

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early and visit an emergency medical center promptly.[6]

In the newly revised 2017 European Society of Cardiology guidelines, the previous concept of door-to-balloon time (DTBT) was eliminated, and the definition of first medical contact (FMC) was emphasized and clarified.[7] FMC is defined as the moment a patient comes into contact with a medical professional (doctor, nurse, or 119 personnel) who can evaluate and interpret electrocardiograms and provide initial treatment including defibrillation. The guidelines mention that FMC can involve emergency medical services (EMS) outside the hospital. They also highly recommend the use of EMS in patients with STEMI, and describe that these services not only are a means of transporting patients but also play an important role in the initial diagnosis and treatment.[7]

According to the National Emergency Department Information System, the EMS utilization rate in Korea in 2019 was approximately 34%, which was higher than the rate in the previous year;[8] however, it was lower than the EMS utilization rate in Japan (78.9%).[9] According to the coronary arteriography guidelines of the American Heart Association (AHA), if a patient with STEMI visits the hospital within 12 hr of symptom onset, it is recommended that coronary arteriography be started within 90 min of hospital arrival.[10] Revascularization within 12 hr in STEMI is a time derived from thrombolysis studies. The definition of latecomer STEMI patients (presenting after 12 hr) is based on the assumption that the infarct-related artery remains permanently occluded before revascularization, resulting in irreversible myocardial loss.[11-13]

Several studies have reported that patients with STEMI who visit the hospital beyond 12 hr after symptom onset have a poor prognosis.[14] A recent study also reported that the mortality risk is 1.5 times higher when the patient arrives at the hospital beyond 12 hr after the onset of symptoms than when the patient visits the hospital within 12 hr.[15] Studies comparing the prognosis of patients with AMI according to the use of EMS have been published.[16] However, in patients who visited a hospital where percutaneous coronary intervention (PCI) could not be administered, it is not possible to accurately determine whether EMS were used.

Therefore, this study aimed to compare the clinical characteristics according to the use of EMS and to identify the factors affecting major complications in patients with STEMI registered in the Korea AMI Registry−National Institutes of Health (KAMIR-NIH). In addition, we aimed to obtain information about the use of EMS in patients with AMI who were followed up for long-term clinical outcomes over 3 years.

MATERIALS AND METHODS

Study design and population

The data pertaining to the study population involved in the present study were derived from the KAMIR-NIH. The current study included data obtained from October 2011 to December 2015. The KAMIR-NIH is a prospective, open, online, multicenter registry that comprises data from more than 20 hospitals in Korea that have resources to perform PCI, and it was established to monitor real-life treatment practices and outcomes in patients with AMI.[17] This study was approved by the Institutional Review Board of Chonnam National University Hospital (CNUH-2021-219).

A total of 13104 patients with AMI were enrolled in KAMIR-NIH. Among them, 2416 patients with STEMI who visited the hospital within 12 hr of symptom onset were enrolled in this study. Patients with Killip class IV are considered to be in an already critical condition, regardless of EMS use. Even if only the Killip class is corrected, when symptoms such as cardiogenic shock (a criterion for Killip class IV) appear in addition to the symptoms of patients analyzed in this study, the patient is judged to already have serious pathological and physiological damage. As Killip class IV can be a variable with a significant impact, it was excluded from this study.[18]

The enrolled patients were classified into two groups according to the use of EMS: 987 patients (age 61.26±12.66 years) in the EMS group and 1429 patients (age 60.84±11.79 years) in the non-EMS group. Propensity score matching (PSM) was performed to reduce bias from confounding variables. After PSM, a total of 1592 patients with STEMI, 796 patients (age 61.07±12.68 years) in the EMS group and 796 patients (age 61.32±11.54 years) in the non-EMS group, were compared (Fig. 1).

Definitions and clinical endpoints

When symptoms occurred in STEMI patients, hospital admission using EMS was classified as the EMS group, and patients visiting the hospital using personal or public transportation were classified as the non-EMS group.

Data on general characteristics, including age, sex, body mass index (BMI), Killip class, comorbidities [hypertension (HTN), diabetes mellitus (DM), dyslipidemia (DL), previous myocardial infarction, angina, heart failure (HF), and cerebrovascular accident (CVA)], and smoking rate were collected. Clinical characteristics based on hematological tests and echocardiographic examinations performed during hospitalization, including left ventricular ejection fraction (LVEF) measurements, were recorded. The lesion characteristics in coronary artery angiographic findings were classified according to the American College of Cardiology (ACC)/AHA classification.[19] The rate of perfusion through the coronary artery lesion was classified according to the Thrombolysis in Myocardial Infarction (TIMI) flow criteria.[20] Major adverse cardiac events (MACE) were defined as all-cause death, recurrent myocardial infarction, repeat PCI, and coronary artery bypass graft surgery during 3 years of clinical follow-up.

Statistical analysis

To minimize the effect of selection bias between the EMS and non-EMS groups, first, a multivariate logistic regression model

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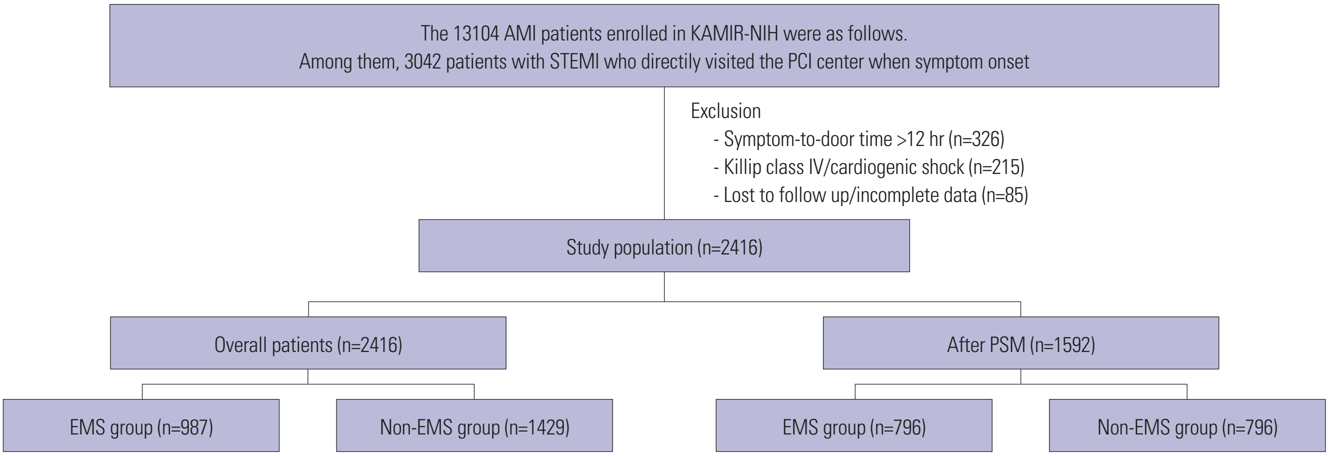

Fig. 1. Study flow chart. AMI, acute myocardial infraction; KAMIR-NIH, Korea Acute Myocardial Infarction Registry-National Institutes of Health; STEMI, ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; PSM, propensity score matching; EMS, emergency medical services.

with an "enter" method was used with the independent variables for all individual outcome components. Only variables with p<0.1 in the univariate analysis were included in the multivariate model. Second, propensity scores (PSs) were estimated using a multivariate logistic regression model for the baseline clinical, angiographic, and procedural characteristics and in-hospital medications. Thereafter, one-to-one matching according to the PS was performed using the nearest- neighbor method within a caliper width of 0.01 of the standard deviation of the logit of the PS. The relevant variables were age, sex, Killip class, HTN, DM, DL, myocardial infarction, angina, HF, CVA, BMI, smoking, and PCI treatment. The PS was calculated using logistic regression and matched 1:1 according to the PS value. The C-statistic for the PS model was 0.708. Continuous variables are presented as mean±standard deviation, and were compared using the Student's t-test. Discrete variables are expressed as percentages and frequencies, and were compared using the chi-square test. Multiple logistic regression and Cox proportional regression analyses were performed to identify the independent predictors of 3-year mortality. The results are presented as adjusted hazard ratios with 95% confidence intervals. Kaplan-Meier curves were compared for all-cause death and MACE, and the log-rank test was used to test the differences in the survival curves. All analyses were two-tailed, and statistical significance was set at p≤0.05. All analyses were performed using SPSS software (version 25.0; IBM Co., Armonk, NY, USA).

RESULTS

Baseline characteristics and medications

No difference in age or sex was found between the two groups. At the time of admission, the EMS group had significantly more patients with Killip class III compared to the non-EMS group. There was a significantly higher proportion of patients with previous angina pectoris in the EMS group than in the non-EMS group. The symptom-to-door time (STDT) was significantly shorter in the EMS group than in the non-EMS group (median 60 min vs. 153 min, p<0.001).

The frequencies of administration of aspirin, clopidogrel, prasugrel, ticagrelor, calcium channel blocker, angiotensin-receptor blocker, angiotensin-converting enzyme inhibitor, and statin during hospitalization were not different between the two groups (Table 1).

After PSM, the STDT was still significantly shorter in the EMS group than in the non-EMS group (median 61 min vs. 97 min, p<0.001). Moreover, there was also no significant difference between the two groups in the medications administered during hospitalization (Table 1).

Laboratory, echocardiographic, and coronary angiographic findings

The levels of creatine kinase-MB fraction and troponin-I were higher in the EMS group than in the non-EMS group.

On echocardiography, no significant difference in LVEF was found between the two groups (Table 1).

The lesion characteristics according to the ACC/AHA classification and target lesion were not different between the two groups. Lesions including the left main disease and three-vessel disease were more frequent in the EMS group than in the non-EMS group. There was no significant difference in TIMI flow between the two groups before and after the procedure (Table 2).

After PSM, the laboratory findings and LVEF were not significantly different between the two groups (Table 1). In addition, there were no significant differences in the ACC/AHA classification, target vessel, and number of involved vessels treated with PCI between the EMS and non-EMS groups (Table 2).

Clinical outcomes

The number of complications during hospitalization was significantly higher in the EMS group. Among the complications,

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Table 1. Clinical Characteristics of EMS and Non-EMS Groups

Variables	Overall patients (n=2416)			After PSM (n=1592)		
	EMS (n=987)	Non-EMS (n=1429)	*p* value	EMS (n=796)	Non-EMS (n=796)	*p* value
Male	817 (82.8)	1184 (82.9)	0.960	661 (83.0)	660 (82.9)	0.947
Age (yr)	61.26±12.66	60.84±11.79	0.405	61.07±12.68	61.32±11.54	0.681
BMI (kg/m^2)	24.43±3.07	24.35±3.18	0.547	24.34±3.06	24.28±3.26	0.705
Dyspnea	208 (21.1)	290 (20.3)	0.641	159 (20.0)	155 (19.5)	0.801
Killip class			0.212			0.245
I	856 (86.7)	1237 (86.6)		688 (86.4)	691 (86.8)	
II	69 (7.0)	120 (8.4)		60 (7.5)	70 (8.8)	
III	62 (6.3)	72 (5.0)		48 (6.0)	35 (4.4)	
Hypertension	468 (47.4)	648 (45.3)	0.316	365 (45.9)	362 (45.5)	0.880
Diabetes mellitus	274 (27.8)	399 (27.9)	0.931	224 (28.1)	226 (28.4)	0.911
Dyslipidemia	122 (12.4)	196 (13.7)	0.333	86 (10.8)	94 (11.8)	0.527
Previous MI	76 (7.7)	108 (7.6)	0.897	62 (7.8)	64 (8.0)	0.853
Previous angina	104 (10.5)	113 (7.9)	0.026	78 (9.8)	67 (8.4)	0.338
Previous HF	9 (0.9)	13 (0.9)	0.996	7 (0.9)	3 (0.4)	0.204
Previous CVA	53 (5.4)	69 (4.8)	0.550	38 (4.8)	42 (5.3)	0.646
Currently smoking	439 (44.5)	651 (45.6)	0.601	353 (44.3)	362 (45.5)	0.650
STDT (min)	95.35±96.47 (median 60)	153.02±154.17 (median 153)	<0.001	98.33±98.51 (median 61)	152.58±153.64 (median 97)	<0.001
≤2 hr	763 (77.3)	844 (59.1)	<0.001	584 (73.4)	451 (56.7)	<0.001
>2 hr	224 (22.7)	585 (40.9)		212 (26.6)	345 (43.3)	
Concomitant medication						
Aspirin	984 (99.7)	1427 (99.9)	0.383	795 (99.9)	796 (100.0)	0.317
Clopidogrel	498 (50.5)	723 (50.6)	0.946	405 (50.9)	419 (52.6)	0.483
Prasugrel	135 (13.7)	204 (14.3)	0.677	121 (15.2)	135 (17.0)	0.339
Ticagrelor	290 (30.9)	366 (34.8)	0.071	230 (28.9)	192 (24.1)	0.061
CCB	47 (4.8)	78 (5.5)	0.447	35 (4.4)	40 (5.0)	0.554
ACEI	552 (55.9)	829 (58.0)	0.309	440 (55.3)	446 (56.0)	0.762
ARB	228 (23.1)	314 (22.0)	0.514	204 (25.6)	192 (24.1)	0.487
Statin	928 (94.0)	1353 (94.7)	0.488	750 (94.2)	746 (93.7)	0.674
Oral anticoagulant	26 (2.6)	39 (2.7)	0.887	19 (2.4)	22 (2.8)	0.635
Echocardiography findings						
LVEF (%)	51.63±10.37	51.17±9.94	0.291	51.65±10.31	50.57±9.70	0.054
Laboratory findings at admission						
Hemoglobin (g/dL)	14.38±1.90	14.60±1.84	0.056	14.43±1.90	14.57±1.87	0.125
Platelet (10^3/μL)	238.19±67.17	236.67±64.41	0.575	239.15±67.46	239.70±64.45	0.868
Glucose (mg/dL)	174.05±69.66	169.79±69.66	0.151	175.31±68.45	170.79±69.54	0.199
Creatinine (mg/dL)	1.05±0.80	1.03±0.70	0.547	1.05±0.84	1.05±0.78	0.918
CK-MB (ng/mL)	163.06±154.46	153.36±157.54	0.036	160.50±160.00	157.69±166.50	0.732
Troponin I (ng/mL)	77.90±173.17	64.76±89.73	0.028	73.18±102.82	65.34±89.07	0.104
hs-CRP (mg/dL)	0.68±2.22	0.70±3.29	0.866	0.56±1.75	0.62±1.75	0.592
NT-pro BNP (pg/mL)	801.58±3308.56	771.17±2708.22	0.843	802.41±3331.71	757.58±2614.87	0.800
Hemoglobin A1C (%)	6.26±1.26	6.46±1.46	0.560	6.31±1.28	6.49±1.51	0.058
ARU (units)	458.68±73.68	445.72±72.53	0.093	457.64±74.47	454.41±72.44	0.754
PRU (units)	159.04±106.86	176.51±105.28	0.051	160.29±104.56	174.57±105.17	0.175

EMS, emergency medical services; PSM, propensity score matching; BMI, body mass index; MI, myocardial infarction; HF, heart failure; CVA, cerebrovascular accident; STDT, symptom-to-door time; CCB, calcium channel blocker; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; LVEF, left ventricular ejection fraction; CK-MB, creatine kinase myocardial band; hs-CRP, high sensitivity C-reactive protein; NT-pro BNP, N-terminal pro-brain natriuretic peptide; ARU, aspirin reactivity units; PRU, platelet reactivity unit.
Data are presented as mean±SD or number (%).

Table 2. Coronary Angiographic Findings and Procedural Characteristics of EMS and Non-EMS Groups

Variables	Overall patients (n=2416)			After PSM (n=1592)		
	EMS (n=987)	Non-EMS (n=1429)	*p* value	EMS (n=796)	Non-EMS (n=796)	*p* value
PCI	961 (97.4)	1393 (97.5)	0.861	793 (99.6)	794 (99.7)	0.654
DTBT (min)	140.02±452.64 (median 62)	294.19±560.21 (median 64)	0.396	121.36±423.38 (median 61)	135.04±457.82 (median 63)	0.536
≤90	843 (87.4)	1209 (86.7)	0.655	699 (87.8)	694 (87.2)	0.705
>90	122 (12.6)	185 (13.3)		87 (12.2)	102 (12.8)	
ACC/AHA type			0.767			0.846
A	15 (1.6)	15 (1.1)		14 (1.8)	11 (1.4)	
B1	107 (11.1)	161 (11.5)		93 (11.7)	90 (11.3)	
B2	286 (29.6)	411 (29.4)		235 (29.5)	248 (31.2)	
C	559 (57.8)	810 (58.0)		454 (57.0)	447 (56.2)	
Target vessel			0.147			0.074
LM	11 (1.1)	13 (0.9)		7 (0.9)	7 (0.9)	
LAD	480 (49.6)	755 (54.0)		393 (49.4)	445 (55.9)	
RCA	383 (39.6)	492 (35.2)		319 (40.1)	275 (34.5)	
LCX	93 (9.6)	137 (9.8)		77 (9.7)	69 (8.7)	
Number of involved vessels			0.025			0.826
LM (simple)	10 (0.9)	4 (0.3)		3 (0.4)	2 (0.3)	
LM (complex)	53 (4.5)	45 (3.0)		22 (2.8)	19 (2.4)	
Singe vessel disease	591 (50.3)	811 (53.7)		440 (55.3)	422 (53.0)	
Two-vessel disease	324 (27.6)	423 (28.0)		220 (27.6)	234 (29.4)	
Three-vessel disease	196 (16.7)	228 (15.1)		111 (13.9)	119 (14.9)	
Pre-PCI TIMI flow ≤2	834 (84.5)	1195 (83.6)	0.565	654 (82.2)	648 (81.4)	0.697
Post-PCI TIMI flow 3	937 (94.9)	1351 (94.5)	0.672	771 (96.9)	770 (96.7)	0.887

EMS, emergency medical services; PSM, propensity score matching; PCI, percutaneous coronary intervention; DTBT, door-to-balloon time; ACC/AHA, American College of Cardiology/American Heart Association; LM, left main artery; LAD, left anterior descending artery; RCA, right coronary artery; LCX, left circumflex artery; TIMI, thrombolysis in myocardial infarction.
Data are presented as mean±SD or number (%).

Table 3. Complications During Hospitalization of EMS and Non-EMS Groups

Variables	Overall patients (n=2416)			After PSM (n=1592)		
	EMS (n=987)	Non-EMS (n=1429)	*p* value	EMS (n=796)	Non-EMS (n=796)	*p* value
Complications						
Cardiogenic shock	76 (7.7)	92 (6.4)	0.231	59 (7.4)	49 (6.2)	0.319
Newly developed HF	32 (3.2)	25 (1.7)	0.017	25 (3.1)	13 (1.6)	0.059
Recurrent ischemia	4 (0.4)	16 (1.1)	0.057	4 (0.5)	13 (1.6)	0.028
Recurrent infarction	1 (0.1)	11 (0.8)	0.022	1 (0.1)	10 (1.3)	0.006
CVA	9 (0.9)	12 (0.8)	0.851	7 (0.9)	11 (1.4)	0.343
VT/VF	76 (7.7)	67(4.7)	0.002	53 (6.7)	36 (4.5)	0.064
AKI	3 (0.3)	1 (0.1)	0.164	2 (0.3)	1 (0.1)	0.563
Treatment						
CPR	63 (6.4)	52 (3.6)	0.002	46 (5.8)	30 (3.8)	0.060
ECMO	9 (0.9)	8 (0.6)	0.309	6 (0.8)	5 (0.6)	0.762
CABG	5 (0.5)	4 (0.3)	0.369	3 (0.4)	1 (0.1)	0.317
IABP	28 (2.8)	24 (1.7)	0.054	24 (3.0)	16 (2.0)	0.200
In-hospital mortality	21 (2.1)	25 (1.7)	0.504	15 (1.9)	14 (1.8)	0.851
Cardiac death	18 (1.8)	23 (1.6)	0.689	15 (1.9)	13 (1.6)	0.703
Non-cardiac death	3 (0.3)	2 (0.1)	0.383	0 (0.0)	1 (0.1)	0.317

EMS, emergency medical services; PSM, propensity score matching; HF, heart failure; CVA, cerebrovascular accident; VT, ventricular tachycardia; VF, ventricular fibrillation; AKI, acute kidney injury; CPR, cardiopulmonary resuscitation; CABG, coronary artery bypass graft; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump.
Data are presented as number (%).

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Table 4. Clinical Outcomes of 3-Year Follow-Up in EMS and Non-EMS Groups

Variables	Overall patients (n=2416)			After PSM (n=1592)			Adjusted analysis		
	EMS (n=987)	Non-EMS (n=1429)	*p* value	EMS (n=796)	Non-EMS (n=796)	*p* value	HR	95% CI	*p* value
All-cause death	57 (5.9)	84 (5.9)	0.946	44 (5.6)	51 (6.5)	0.486	1.189	0.791–1.789	0.405
Cardiac death	42 (4.3)	54 (3.8)	0.534	35 (4.5)	31 (3.9)	0.589	0.899	0.550–1.469	0.671
Recurrent MI	36 (3.8)	42 (3.0)	0.310	33 (4.3)	27 (3.5)	0.406	0.471	0.440–1.248	0.260
Repeat PCI	67 (7.1)	100 (7.2)	0.896	46 (6.0)	52 (6.7)	0.566	1.136	0.763–1.691	0.530
CABG	2 (0.2)	2 (0.1)	0.702	2 (0.3)	2 (0.3)	0.992	0.608	0.072–5.123	0.647
MACE	139 (14.7)	198 (14.3)	0.794	108 (14.1)	115 (14.8)	0.672	1.047	0.803–1.365	0.735

EMS, emergency medical services; PSM, propensity score matching; CI, confidence interval; HR, hazard ratio; MI, myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; MACE, major adverse cardiac events.
Data are presented as number (%).

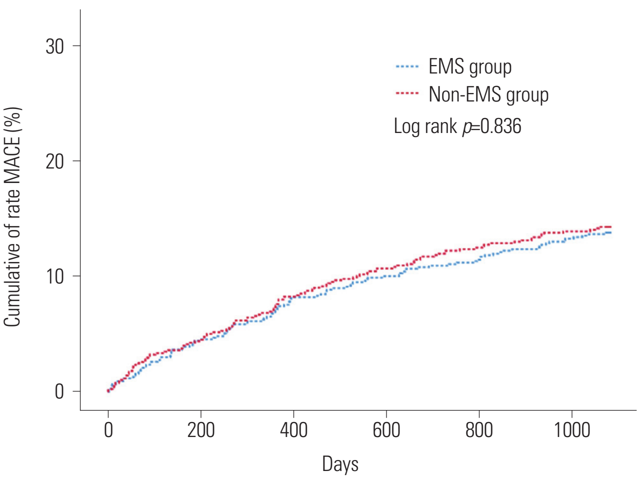

Fig. 2. Kaplan-Meier curve for MACE in ST-segment elevation myocardial infarction patients according to EMS use. MACE, major adverse cardiac events; EMS, emergency medical services.

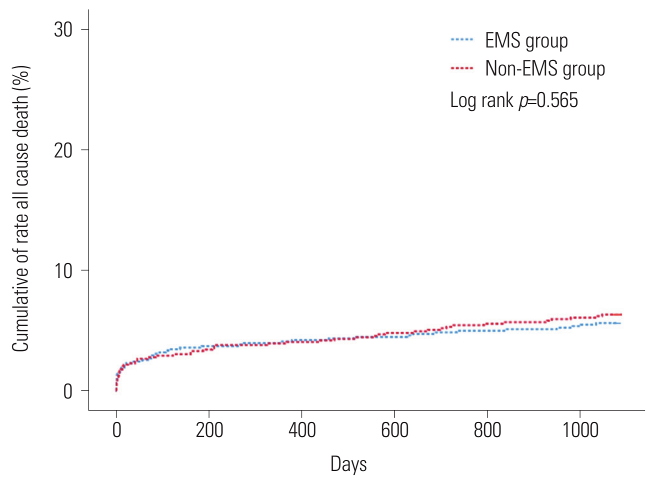

Fig. 3. Kaplan-Meier curve for all-cause death in ST-segment elevation myocardial infarction patients according to EMS use. EMS, emergency medical services.

newly developed HF, and ventricular tachycardia/ventricular fibrillation were more common in the EMS group. In contrast, recurrent infarction more frequently occurred in the non-EMS group. In terms of supportive care, cardiopulmonary resuscitation was more frequently performed in the EMS group than in the non-EMS group. The rates of all-cause, cardiac, and noncardiac deaths during hospitalization were not different between the EMS and non-EMS groups (Table 3).

After PSM, recurrent ischemia and infraction were more frequent in the non-EMS group. The rate of in-hospital mortality was not different between the two groups (Table 3).

During the 3-year clinical follow-up, the rates of all-cause death and MACE did not differ between the EMS and non-EMS groups. After PSM, the rates of all-cause death and MACE were still not significantly different between the non-EMS and EMS groups (Table 4).

Kaplan-Meier survival curve analysis showed that the rates of MACE and all-cause death were not significantly different between the groups (Figs. 2 and 3).

Kaplan-Meier survival curve analysis showed that the rates of MACE and all-cause death were not significantly different between the groups including Killip class IV (Supplementary Fig. 1, only online).

Predictive factors of 3-year mortality

The predictors of mortality in patients with STEMI during the 3-year clinical follow-up were high Killip class, high creatinine level (>1.3 mg/dL), old age >65 years, DTBT >90 min, STDT >120 min, and low LVEF (<40%) (Table 5).

DISCUSSION

The purpose of this study was to investigate the differences in clinical characteristics and long-term prognosis according to the use of EMS in patients with STEMI who arrived at the hospital within 12 hr of symptom onset, as well as to analyze the factors affecting prognosis in these patients. In terms of the general patient characteristics at the time of admission, a high Killip class was found to be associated with the use of EMS. In previous studies, patients with STEMI with a high Killip class had poor prognosis.[21] Moreover, a high Killip class is known to be a factor affecting patient prognosis.[22] In a study conducted in Canada, the EMS group showed higher mortality and 33% of the patients in this group died within 1 hr of arriving at the hospital. The study attributed this finding to the higher number of high-risk patients in the EMS group than in the non-EMS

Table 5. Cox Regression Analysis for Independent Predictors of 3-Year Mortality in STEMI Patients (n=1592)

	Univariate analysis			Multivariate analysis		
	HR	95% CI	*p* value	HR	95% CI	*p* value
Female, sex	1.483	0.841–2.615	0.174			
No use EMS	1.185	0.727–1.933	0.496			
Age ≥65 years	2.404	1.003–5.759	0.049	4.033	2.349–6.925	<0.001
Killip class III	5.291	3.198–8.754	<0.001	2.069	1.076–3.979	0.029
Smoking	1.118	0.605–2.065	0.721			
Previous MI	1.121	0.520–2.418	0.771			
CVA	1.886	0.909–3.828	0.089			
LVEF <40%	2.937	1.748–4.932	<0.001	2.684	1.605–4.490	<0.001
Creatinine >1.3 mg/dL	2.088	1.150–3.788	0.015	2.209	1.291–3.782	0.004
STDT >120 min	2.510	1.583–3.730	0.027	1.875	1.336–2.943	0.031
DTBT >90 min	2.263	1.108–3.476	0.041	2.014	1.224–3.315	0.006

STEMI, ST-segment elevation myocardial infarction; HR, hazard ratio; CI, confidence interval; EMS, emergency medical services; CVA, cardiovascular accident; MI, myocardial infarction; LVEF, left ventricular ejection fraction; STDT, symptom-to-door time; DTBT, door-to-balloon time.
HR was calculated by Cox regression analysis.

group.[23] Furthermore, the National Registry of Myocardial Infarction study, which analyzed 772586 patients with AMI involving 1674 hospitals in the United States, also showed higher mortality in the EMS group than in the self-transport group.[24] In a Korean study, patients who used EMS also had significantly higher mortality than those who did not; however, there was no difference in mortality between the two groups after correction for risk factors.[25] Nevertheless, the reasons for using EMS are that these services can immediately provide personnel and equipment in cases of cardiac arrest that occur outside the hospital, in addition to the advantage of transporting patients suspected of having AMI to an appropriate cardiac hospital.[24]

In the current study, the average time from symptom onset to hospital arrival was 61 min in the EMS group and 97 min in the non-EMS group, which translates to a >1.6-times difference. Although previous studies have shown that early arrival at the hospital has a significant effect on treatment and prognosis,[26] further studies with more participants may be needed to confirm the effect on prognosis of the 30-min time difference shown in this study. Moreover, a Korean study showed that 73.6% of all patients with AMI were transferred to a primary PCI center from a non-PCI center and 4.1% of them were transferred from two or more hospitals.[27]

In other countries, the reasons of patients for non-utilization of EMS despite the known benefits include false awareness of symptoms, the belief that directly going to the hospital using their own transportation would be faster,[28] and the cost of EMS.[29] In Korea, EMS are provided free of charge; however, some patients prefer not to use these services to avoid unwanted attention from other people and the relatively higher cost of visiting the emergency room rather than the outpatient clinic.[30] In a previous study, patients who were directly transported to a primary PCI center via EMS had a significantly higher probability of undergoing timely primary PCI than patients transferred from other hospitals.[31] This shows that patients using EMS can immediately receive treatment upon hospital arrival because basic procedures such as patient identification and electrocardiography (ECG) measurements have already been performed by paramedics during the transportation. In previous studies, the use of EMS was associated with good patient prognosis by enabling the diagnosis of STEMI at an early stage through ECG examinations during patient transport, which allows prompt treatment on arrival at the hospital.[32]

As shown in this study, the time from hospital arrival to reperfusion is a factor that affects mortality. In previous studies, patients with prolonged DTBT had a poor prognosis, and DTBT was reported to be a factor that increases mortality.[33-36]

In addition, a previous study demonstrated that the use of EMS shortened the DTBT, as 27% of patients transferred via EMS had already undergone ECG examinations before arriving at the hospital.[37] Nevertheless, although EMS utilization is a major factor in shortening the reperfusion time, another study reported that 36.2% of EMS users were transferred to a hospital that cannot administer PCI.[6]

According to the National Emergency Department Information System in 2015, the rate of EMS use among patients with AMI was approximately 30%.[38] However, in the same year (2015), the KAMIR reported that only 17.2% of patients with AMI visited a PCI center through EMS.[39] This may suggest that EMS did not transfer the patients to an appropriate PCI center but to non-PCI centers. Therefore, it is necessary to establish and develop processes that facilitate patient transfer between EMS and PCI centers. As mentioned above, patients with AMI often die before receiving treatment. Therefore, it is necessary to promptly recognize the symptoms and respond to the patient's needs. EMS offer the best solution for this purpose. Hospitals and the government need to provide public education on the symptoms of AMI and promote the use of EMS through mass media, such as newspapers and TV broadcasts.

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This study had some limitations. It was not possible to accurately determine the mortality rate of patients with AMI since patients who died before arriving at the hospital were not identified. In addition, the participating centers were large hospitals where the patients' prognosis can be relatively good compared to other small- and medium-sized hospitals. Although the patients' areas of residence were not analyzed, the participating PCI centers in this study were hospitals located in large cities and many patients probably lived close to metropolitan areas. Therefore, the use of EMS in remote areas that require medical support was insufficiently analyzed as patients living in mountainous or island areas were not identified. Studies on the use of EMS in patients with AMI should cover all regions to find strategies to reduce the medical disparity between regions. As EMS do not transfer patients with myocardial infarction directly to a PCI center and instead transfer them to a non-PCI center, this aspect should be considered in future studies.

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AUTHOR CONTRIBUTIONS

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