Multicenter Cohort Study of Acute Myocardial Infarction in Korea

– Interim Analysis of the Korea Acute Myocardial Infarction Registry-National Institutes of Health Registry –

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Background: The Korea Acute Myocardial Infarction Registry (KAMIR)-National Institutes of Health (NIH) registry has the aim of evaluating the clinical characteristics, management, and long-term outcomes of patients with acute myocardial infarction (AMI) in Korea.

Methods and Results: Patients hospitalized for AMI in 20 tertiary university hospitals in Korea have been enrolled since November 2011. The study is expected to complete the scheduled enrollment of approximately 13,000 patients in October 2015, and follow-up duration is up to 5 years for each patient. As of October 2015, an interim analysis of 13,623 subjects was performed to understand the baseline clinical profiles of the study population. The mean age was 64.1 years; 73.5% were male; and 48.2% were diagnosed with ST-segment elevation AMI. Hypertension is a leading cause of AMI in Korea (51.2%), followed by smoking (38.5%) and diabetes mellitus (28.6%). Percutaneous coronary intervention was performed in 87.4% and its success rate was very high (99.4%). In-hospital, 1-year, and 2-year mortality rates were 3.9%, 4.3%, and 8.6%, respectively. The rates of major adverse cardiac events at 1 and 2 years were 9.6% and 18.8%, respectively.

Conclusions: This analysis demonstrated the clinical characteristics of Korean AMI patients in comparison with those of other countries. It is necessary to develop guidelines for Asian populations to further improve their prognosis. (*Circ J* 2016; **80**: 1427–1436)

Key Words: Multicenter study; Myocardial infarction; Research design

Acute myocardial infarction (AMI) is a leading cause of death around the world.^{1,2} In Korea, as in other developed countries, the incidence of AMI has increased over several decades. It is important to prevent the occurrence of AMI, and to manage the patients for a long time after surviving an AMI. To improve the prognosis, we needed to investigate the risk factors, clinical features, use of medica-

tions, and procedural findings of AMI in Korean patients. The Korea Acute Myocardial Infarction Registry (KAMIR) was launched for this purpose by the Korean Society of Cardiology in 2005.^{3–7} However, there were some limitations in the KAMIR, including lack of long-term follow-up, despite a great expansion in the number of enrollments. Therefore, there has been a systematic effort to develop a national registry funded by the

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National Institutes of Health (NIH) for better understanding of AMI in Korea. The authors have established this registry to identify the overall clinical features, current treatment strategies, and prognosis of patients with AMI in Korea and to compare this registry with those from other countries.

Methods

Objectives of the Registry

The KAMIR-NIH registry (<http://www.kamir.or.kr>) is a prospective, open, observational, and on-line registry with a multicenter cohort study that is currently ongoing. The registry protocols of KAMIR-NIH were verified and approved by the institutional review board of each participating center. Patients with a diagnosis of AMI at presentation to hospital have been enrolled and followed up continuously. The aims of the KAMIR-NIH are as follows: (1) to collect data on baseline clinical characteristics, current treatment patterns, and short- and long-term patient outcomes; (2) to analyze the prognostic factors of AMI; and (3) to improve the long-term prognosis of individual patients.

Patients

Patients hospitalized for AMI from 20 tertiary university hospitals capable of percutaneous coronary intervention (PCI) have been consecutively enrolled since November 2011 throughout Korea. The planned enrollment of approximately 13,000 patients is expected to be complete in October 2015, with follow-up through 2018. AMI is defined as cardiomyocyte necrosis in a clinical setting consistent with acute myocardial ischemia.⁸ AMI was diagnosed by the characteristic presentation, serial changes on ECG suggesting infarction, and an increase in cardiac markers, preferably cardiac troponins, with at least one value above the 99th percentile of the upper reference limit. ST-segment elevation MI (STEMI) was defined as new ST elevation in ≥ 2 contiguous leads, measuring >0.2 mV in leads V1–3 or 0.1 mV in all other leads, or a new left bundle branch block on 12-lead ECG with a concomitant increase in troponin-I or -T.

Data Collection

Written informed consent was given by each patient. If patients were unable to give consent because of disease severity, informed consent was obtained from a relative or legal representative. Data were collected by the attending physician with the assistance of a trained clinical research coordinator, via a web-based case report form in the Clinical Data Management System (iCReaT) of the Korea NIH. The KAMIR-NIH registry documented all consecutive variables and values at baseline admission of patients with AMI in Korea. The cardiovascular risk factors (hypertension, diabetes mellitus, dyslipidemia, smoking, and family history of coronary artery disease) and other comorbidities were identified. The baseline data included the initial presentation and laboratory results at the emergency department. During the in-hospital period, events including all-cause death, cardiac death, and any complications related to AMI were recorded. After discharge, all major adverse cardiac events (MACE) including cardiac death, MI, repeat PCI (target lesion or target vessel revascularization, or non-target vessel revascularization), stent thrombosis, or coronary bypass graft, and all events of non-cardiac death, cerebrovascular accident, and re-hospitalization because of heart failure were recorded at 6, 12, 24, and 36 months. The follow-up results of echocardiography, laboratory studies, and prescribed medications were also recorded at 12, 24, and 36

months. The follow-up data were collected from the patients by attending physicians and the web-based case report forms were completed. If the patients did not visit the hospitals, the outcome data were assessed by telephone interview.

Study Management

The registry is governed and managed by a committee consisting of healthcare professionals with expertise in AMI. The committee designed the study protocol and case report forms. The committee supervises all activities related to publications from the aggregate database. The present study is funded by the Korea NIH.

Statistical Methods and Sample Size Determination

Determination of Sample Size and Study Power For determination of sample size, we selected the timeliness of reperfusion therapy as a representative index. From the previous KAMIR data set, a total of 10,950 (53%) patients were diagnosed with STEMI and underwent PCI. Among these patients, 47% were untimely (>90 min) [$\Pr(x=1)$]. The mortality rate of patients who experienced appropriate reperfusion therapy (≤ 90 min), was 7% within 1 year [$\Pr(y=1/x=0)$]. We presumed that the odds ratio (OR) of death in 1 year because of delayed reperfusion therapy was 1.3, which minimally expected 80% of the OR of 1.57 in a previous study.⁹ To observe $>80\%$ power and an alpha of 0.05, we needed a sample size of 6,293 calculated by StudySize software (ver. 2.0.4; CreosStat HB, Sweden). In addition, we presumed that the rate of follow-up loss was approximately 10%, requiring a total of 6,923 STEMI patients. Therefore, a total of 13,000 AMI patients were planned to be enrolled in this study, because the proportion of STEMI was 53%. We estimated that a total of 3,000 AMI patients would be annually enrolled from 20 centers, and that we might need 4 years to complete this cohort study.

Statistical Analysis For continuous variables, the data are expressed as the mean $\pm$ standard deviation or as the median with an interquartile range using unpaired t-test or Mann-Whitney rank-sum test. For categorical variables, the data are expressed as counts and percentage and analyzed by the Chi-square (or Fisher's exact) test. Cumulative 2-year MACE-, cardiac death-, and repeat PCI-free survival curves were constructed from Kaplan-Meier survival analyses and compared using log-rank test. All analyses were two-tailed, with clinical significance defined as $P < 0.05$. Statistical analysis was performed using SPSS, version 21.0 for Windows (SPSS-PC, Chicago, IL, USA) and R, version 3.2.2.

Results

A total of 13,623 Korean patients with AMI were enrolled in this study until October 2015. We excluded patients whose clinical data were incomplete for interim analyses. A total of 12,956 patients were enrolled at 20 hospitals around Korea.

Demographics and Baseline Clinical Characteristics

The clinical characteristics of the patients in KAMIR-NIH are shown in [Table 1](#), and they are compared with other AMI registries including GRACE,¹⁰ SCAAR,¹¹ NRMI,¹² MINAP,¹³ and SWEDHEART/RIKS-HIA.¹³ The mean age was 64.1 years and 73.5% were male. Less than half of the patients (48.2%) were diagnosed as STEMI. Among the risk factors for ischemic heart disease, hypertension was the most common comorbidity (51.2%), followed by smoking (38.5%), diabetes mellitus (28.6%), dyslipidemia (11.2%), previous MI (8.1%), family history (6.3%), and cerebrovascular accident

Table 1. Clinical Characteristics of Patients With Acute MI in Korea Compared With Other Registries

	KMAIR-NIH	KAMIR ⁵	GRACE ¹⁰	SCAAR ¹¹	NRMI ¹²	MINAP ¹³	SWEDHEART/ RIKS-HIA ¹³
Region	South Korea	South Korea	Europe, America	Sweden	US	UK	Sweden
Time period	Nov 2011– Oct 2015	Nov 2005– Oct 2010	2004–2007	Jan 2003– Dec 2004	1994–2006	Jan 2004– Dec 2010	Jan 2004– Dec 2010
Sample size	13,624	27,852	28,449	19,771	542,008	391,077	119,786
Follow-up rate (%)	97.1*	NA	89.8	95.2	NA	NA	NA
Follow-up duration	525.6 days	231.6 days	2 years	3 years	NA	NA	NA
Demographics							
Mean or median age (years)	64.1	63.2	65.0	65.7	64.0	69.5	71.2
Male (%)	73.5	75.0	68.4	72.0	59.0	65.2	63.7
Comorbidities (%)							
Hypertension	51.2	45.9	64.7	44.5	52.3	47.3	45.2
DM	28.6	24.6	25.2	18.1	22.4	17.6	22.7
Dyslipidemia	11.2	9.5	53.0	NA	28.0	NA	NA
Smoking	38.5	62.8	59.8	20.4	31.3	29.5	23.3
Previous MI	8.1	11.1	30.3	37.4	NA	18.3	22.4
Family history of CAD	6.3	7.9	NA	NA	28.0	NA	NA
CVA	6.2	5.6	NA	6.0	NA	8.5	10.1
HF	1.8	1.1	8.8	7.4	NA	5.3	9.7
Vital signs							
SBP (mmHg)	129.9	126.8	NA	NA	147.0	139.0	145.0
DBP (mmHg)	78.4	78.0	NA	NA	NA	NA	NA
Pulse rate (/min)	78.7	76.4	NA	NA	86.0	79.0	78.0
STEMI (%)	48.2	56.6	35.9	22.6	41.8	40.3	32.1
Multivessel disease (%)	54.3	52.7	NA	50.0	NA	NA	NA
Culprit artery (%)							
LM	2.3	1.2	NA	1.3	NA	NA	NA
LAD	46.7	52.7	NA	44.7	NA	NA	NA
LCX	17.5	9.5	NA	21.5	NA	NA	NA
RCA	33.7	36.6	NA	28.8	NA	NA	NA
PCI rate (%)	87.4	84.2	NA	NA	64.0	39.7	87.9
DES (%)	96.9	91.1	NA	30.5	NA	NA	NA
PCI success rate (%)	99.4	99.0	NA	NA	NA	NA	NA
In-hospital mortality (%)	3.9	2.0	NA	NA	8.0	10.6	7.7
1-year mortality (%)	4.3	3.1	NA	NA	NA	NA	NA
2-year mortality (%)	8.6	NA	5.7	NA	NA	NA	NA
3-year mortality (%)	NA	NA	NA	7.2	NA	NA	NA

*Rate of follow-up at 6 months. CAD, coronary artery disease; CVA, cerebrovascular accident; DBP, diastolic blood pressure; DES, drug eluting stents; DM, diabetes mellitus; GRACE, the Global Registry of Acute Coronary Events; HF, heart failure; KAMIR, Korea Acute Myocardial Infarction Registry; LAD, left anterior descending artery; LCX, left circumflex artery; LM, left main; MI, myocardial infarction; MINAP, Myocardial Ischaemia National Audit Project; NA, not available; NIH, National Institutes of Health; NRMI, National Registry of Myocardial Infarction; PCI, percutaneous coronary intervention; RCA, right coronary artery; SBP, systolic blood pressure; SCAAR, Swedish Coronary Angiography and Angioplasty Registry; STEMI, ST-segment elevation myocardial infarction; SWEDHEART/RIKS-HIA, Swedish Web-System for Enhancement and Development of Evidence-Based Care in Heart Disease Evaluated According to Recommended Therapies/ Register of Information and Knowledge about Swedish Heart Intensive care Admissions; UK, United Kingdom; US, United States.

(6.2%). In **Table 2**, we compare the baseline characteristics according to the diagnosis: STEMI vs. non-STEMI (NSTEMI). STEMI patients were younger (62.8 ± 12.8 years vs. 65.1 ± 12.4 years, $P < 0.001$), male-predominant (77.7% vs. 70.6% , $P < 0.001$), and more obese (body mass index $24.1 \pm 3.4 \text{ kg/m}^2$ vs. $23.9 \pm 3.5 \text{ kg/m}^2$, $P = 0.012$) than NSTEMI patients. Although most of the patients with STEMI (90.8%) complained of chest pain, only 19.9% utilized the emergency medical service in Korea. Hypertension (54.8% vs. 47.0% , $P < 0.001$), diabetes mellitus (32.0% vs. 24.8% , $P < 0.001$), dyslipidemia (11.8% vs. 10.6% , $P = 0.022$), cerebrovascular accident (7.5% vs. 4.8% , $P < 0.001$), and heart failure (2.3% vs. 0.9% , $P < 0.001$) were more fre-

quent in patients with NSTEMI than STEMI. Only smoking was more frequent in STEMI patients (43.9% vs. 34.4% , $P < 0.001$). STEMI patients had a higher Killip class (22.8% vs. 20.2% , $P < 0.001$) and a higher proportion of significant atrio-ventricular block (1.4% vs. 0.6% , $P < 0.001$).

Baseline Laboratory and Echocardiographic Findings

As shown in **Table 3**, the mean white blood cell count was higher ($11,500 \pm 4,200/\text{mm}^3$ vs. $9,600 \pm 5,000/\text{mm}^3$, $P < 0.001$) and the proportion of lymphocyte count ($25.3 \pm 14.3\%$ vs. $24.0 \pm 11.8\%$, $P < 0.001$) was higher in patients with STEMI. Although the mean level of glucose at presentation was higher

Table 2. Comparison of Baseline Characteristics of Patients With Diagnosis of STEMI and NSTEMI

	STEMI (n=6,246)	NSTEMI (n=6,710)	P value
Age (years)	62.8±12.8	65.1±12.4	<0.001
Sex (%)			<0.001
Male	4,853 (77.7)	4,738 (70.6)	
Female	1,393 (22.3)	1,972 (29.4)	
Height (cm)	165.4±8.4	163.8±8.7	<0.001
Weight (cm)	66.2±12.0	64.5±12.1	<0.001
BMI (kg/m²)	24.1±3.4	23.9±3.5	0.012
AC (cm)	87.7±8.9	87.4±9.0	0.270
Symptoms			
Chest pain	5,673 (90.8)	5,500 (82.0)	<0.001
Dyspnea	1,261 (20.2)	1,800 (26.8)	<0.001
Previous angina	1,346 (21.5)	1,973 (29.4)	<0.001
First medical contact			<0.001
PCI center	1,758 (28.1)	2,437 (36.3)	
Non-PCI center	3,248 (52.0)	3,547 (52.9)	
EMS	1,240 (19.9)	726 (10.8)	
Previous history			
MI	370 (5.9)	645 (9.6)	<0.001
PCI	518 (8.3)	926 (13.8)	<0.001
CABG	25 (0.4)	94 (1.4)	<0.001
Risk factors			
Hypertension	2,935 (47.0)	3,677 (54.8)	<0.001
DM	1,551 (24.8)	2,149 (32.0)	<0.001
Smoking	2,744 (43.9)	2,305 (34.4)	<0.001
Dyslipidemia	659 (10.6)	794 (11.8)	0.022
Family history	380 (6.1)	444 (6.6)	0.228
CVA	302 (4.8)	502 (7.5)	<0.001
HF	56 (0.9)	155 (2.3)	<0.001
Physical findings			
SBP (mmHg)	125.3±31.9	134.3±28.2	<0.001
DBP (mmHg)	76.5±20.1	80.4±16.7	<0.001
Heart rate (beats/min)	76.9±20.7	80.1±18.6	<0.001
Killip class			<0.001
I	4,801 (77.2)	5,340 (79.8)	
II–IV	1,445 (22.8)	1,370 (20.2)	
ECG findings			
Sinus rhythm	5,308 (85.0)	5,896 (87.9)	<0.001
AV block (II/III)	89 (1.4)	38 (0.6)	<0.001
AF/AFL	340 (5.4)	348 (5.2)	0.540
VT/VF	88 (1.4)	51 (0.8)	<0.001

Data given as number (%) or mean±SD. AC, abdominal circumference; AF, atrial fibrillation; AFL, atrial flutter; AV, atrioventricular; BMI, body mass index; CABG, coronary artery bypass graft; DBP, diastolic blood pressure; ECG, electrocardiogram; EMS, emergency medical service; NSTEMI, non-STEMI; SD, standard deviation; VF, ventricular fibrillation; VT, ventricular tachycardia. Other abbreviations as in Table 1.

in STEMI patients (178.3±81.8 mg/dl vs. 161.8±82.1 mg/dl, $P<0.001$), there was no significant difference in hemoglobin A1c levels (6.5%±1.5% vs. 6.5±1.5%, $P=0.069$). Patients with STEMI had higher levels of total cholesterol (180.6±46.1 mg/dl vs. 175.0±46.4 mg/dl, $P<0.001$), triglyceride (139.8±124.5 mg/dl vs. 128.9±114.9 mg/dl, $P<0.001$), and low-density lipoprotein (LDL) cholesterol (113.8±38.7 mg/dl vs. 109.6±39.6 mg/dl, $P<0.001$) than patients with NSTEMI. The mean left ventricular ejection fraction at presentation was lower in STEMI patients (50.1±10.4% vs. 53.5±11.7%, $P<0.001$).

Comparison of the Medications Prescribed During Hospitalization

The medications prescribed during hospitalization of the STEMI and NSTEMI patients are shown in [Table 4](#). In Korea, almost all patients are treated with aspirin whether they are diagnosed as STEMI (99.6%) or NSTEMI (99.4%). Clopidogrel was more frequently prescribed for NSTEMI patients (82.4% vs. 74.8%, $P<0.001$), whereas prasugrel and ticagrelor were more often used for STEMI patients (14.4% vs. 9.6%, $P<0.001$ and 21.5% vs. 18.0%, $P<0.001$, respectively). Beta-blockers and renin-angiotensin-aldosterone system blockers were used

Table 3. Baseline Laboratory and Echocardiographic Findings in Patients With Diagnosis of STEMI and NSTEMI

	STEMI (n=6,246)	NSTEMI (n=6,710)	P value
Laboratory findings			
WBC (/mm ³)	11,500±4,200	9,600±5,000	<0.001
Neutrophils (%)	66.3±16.3	66.6±14.1	0.350
Lymphocytes (%)	25.3±14.3	24.0±11.8	<0.001
Hemoglobin (g/dl)	14.2±3.4	13.4±2.2	<0.001
Platelets (×1,000/mm ³)	236.1±68.3	229.1±68.6	<0.001
Glucose (mg/dl)	178.3±81.8	161.8±82.1	<0.001
Creatinine (mg/dl)	1.0±0.8	1.2±2.9	<0.001
Total cholesterol (mg/dl)	180.6±46.1	175.0±46.4	<0.001
Triglyceride (mg/dl)	139.8±124.5	128.9±114.9	<0.001
HDL-C (mg/dl)	42.6±12.3	43.1±12.7	0.054
LDL-C (mg/dl)	113.8±38.7	109.6±39.6	<0.001
CK-MB (ng/ml)	166.4±189.6	58.5±115.4	<0.001
Troponin-I (ng/ml)	80.4±396.3	22.1±54.4	<0.001
NT-proBNP (pg/ml)	1,693.8±4,889.2	3,491.2±7,360.7	<0.001
hs-CRP (mg/dl)	1.6±12.8	5.6±234.0	0.295
HbA1c (%)	6.5±1.5	6.5±1.5	0.069
Aspirin reaction units	456.8±76.3	462.5±72.6	0.042
P2Y12 reaction units	182.2±108.7	218.1±108.2	<0.001
Echocardiographic findings			
LVEF (%)	50.1±10.4	53.5±11.7	<0.001
RWMI	1.5±0.4	1.4±0.4	<0.001
LVEDD (mm)	35.2±8.2	34.8±8.6	0.034
LVEDD (mm)	49.6±6.4	49.8±6.9	0.089
LVESV (ml)	48.3±23.0	47.0±27.3	0.046
LVEDV(ml)	95.3±47.6	94.7±36.3	0.572

Data expressed as mean±SD. CK-MB, creatine kinase-MB; Hb, hemoglobin; HDL-C, high-density lipoprotein cholesterol; hs-CRP, high-sensitivity C-reactive protein; LDL-C, low-density lipoprotein cholesterol; NT-proBNP, N-terminal pro B-type natriuretic peptide; LVEDD, left ventricular end-diastolic diameter; LVEDV, left ventricular end-diastolic volume; LVEF, left ventricular ejection fraction; LVESD, left ventricular endsystolic diameter; LVESV, left ventricular endsystolic volume; RWMI, regional wall motion index; WBCC, white blood cell count. Other abbreviations as in Tables 1,2.

Table 4. Comparison of the Medications Prescribed During Hospitalization of Patients With Diagnosis of STEMI and NSTEMI

	STEMI (n=6,246)	NSTEMI (n=6,710)	P value
Antiplatelet agents*			
Aspirin	6,223 (99.6)	6,670 (99.4)	0.082
Clopidogrel	4,674 (74.8)	5,527 (82.4)	<0.001
Cilostazol	685 (11.0)	693 (10.3)	0.250
Prasugrel	898 (14.4)	645 (9.6)	<0.001
Ticagrelor	1,342 (21.5)	1,208 (18.0)	<0.001
β-blockers	5,169 (82.8)	5,304 (79.0)	<0.001
ACEIs	3,223 (51.6)	2,747 (40.9)	<0.001
ARBs	1,639 (26.2)	2,408 (35.9)	<0.001
CCBs	257 (4.1)	797 (11.9)	<0.001
Statin	5,622 (90.0)	6,008 (89.5)	0.392
Omega-3 fatty acid	214 (3.4)	161 (2.4)	0.001
Oral hypoglycemic agents	1,041 (16.7)	1,302 (19.4)	<0.001

Data expressed as number (%). *All cases of patients using any antiplatelet agent at loading or maintenance dose are included. ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; CCB, calcium-channel blocker. Other abbreviations as in Tables 1,2.

Table 5. Baseline Coronary Angiographic Findings and Procedural Characteristics in STEMI and NSTEMI Patients

	STEMI (n=6,246)	NSTEMI (n=6,710)	P value
Coronary angiography (%)	6,202 (99.3)	6,539 (97.5)	<0.001
PCI (%)	6,038 (96.7)	5,560 (82.9)	<0.001
Vascular access route (%)			<0.001
Transradial approach	1,524 (25.2)	2,774 (49.8)	
Transfemoral approach	4,484 (74.2)	2,699 (48.5)	
Both	34 (0.6)	92 (1.7)	
No. of involved vessels (%)			
No significant stenosis	64 (1.0)	442 (6.8)	<0.001
1	3,243 (52.3)	2,688 (41.1)	<0.001
2	1,729 (27.9)	1,818 (27.8)	0.940
3	975 (15.4)	1,217 (18.6)	<0.001
LM complex	179 (2.9)	338 (5.2)	<0.001
LM isolated	30 (0.5)	36 (0.6)	0.688
Target lesion location (%)			
LAD	3,081 (51.0)	2,338 (42.0)	<0.001
LCX	570 (9.4)	1,459 (26.2)	<0.001
RCA	2,303 (38.1)	1,612 (28.9)	<0.001
LM	96 (1.6)	172 (3.1)	<0.001
ACC/AHA type (%)			
A	47 (0.8)	108 (1.9)	<0.001
B1/B2	2,711 (45.2)	2,955 (53.3)	<0.001
C	3,234 (54.0)	2,476 (44.7)	<0.001
Preprocedural TIMI flow 0 (%)	3,816 (63.7)	1,594 (28.8)	<0.001
Postprocedural TIMI flow 3 (%)	5,747 (95.5)	5,418 (97.7)	<0.001
Stent type (%)			
Bare-metal stent	180 (3.0)	170 (3.1)	0.868
Paclitaxel-eluting stent	7 (0.1)	7 (0.1)	1.000
Sirolimus-eluting stent	66 (1.1)	74 (1.3)	0.283
Zotarolimus-eluting stent	1,269 (21.0)	1,147 (20.6)	0.585
Everolimus-eluting stent	2,728 (45.2)	2,508 (45.1)	0.874
Biolimus-eluting stent	1,041 (17.3)	957 (17.2)	0.947
Other DES	358 (5.9)	231 (4.2)	<0.001
Stent length (mm)	25.1±7.1	24.6±7.6	0.001
Stent diameter (mm)	3.2±0.4	3.1±0.4	<0.001
Multivessel PCI (%)	860 (14.3)	1,507 (27.2)	<0.001
Staged PCI (%)	689 (11.4)	384 (6.9)	<0.001
PCI success rate (%)	5,996 (99.4)	5,526 (99.5)	0.247
Additional testing			
IVUS	1,087 (17.4)	1,222 (18.2)	0.239
FFR	37 (0.6)	116 (1.7)	<0.001
OCT	124 (2.0)	148 (2.2)	0.416

Data expressed as number (%) or mean±SD. ACC/AHA, American College of Cardiology/American Heart Association; FFR, fractional flow reserve; IVUS, intravascular ultrasound; OCT, optical coherence tomography; TIMI, Thrombolysis In Myocardial Infarction. Other abbreviations as in Tables 1,2.

in approximately 80% of all patients. Angiotensin-converting enzyme inhibitors were used in 51.6% of STEMI patients and 40.7% of NSTEMI patients. Angiotensin II receptor blockers were also used in one-third of all patients: 26.2% of STEMI and 35.9% of NSTEMI. Almost all patients (90%) were prescribed a statin whether they were diagnosed as STEMI or NSTEMI.

Coronary Angiographic and Procedural Findings

As shown in Table 1 and Table 5, coronary angiography was

performed in almost all the patients, but more commonly in the patients with STEMI (99.3% vs. 97.5%, $P<0.001$). The overall rate of PCI in all patients was 87.4%: 96.7% of STEMI and 82.9% of NSTEMI. The procedural success rate of was very high, regardless of the diagnosis (98.5% in STEMI; 98.9% in NSTEMI; $P=0.088$). The transfemoral approach was used more frequently than the transradial approach in STEMI patients (74.2% vs. 25.2%, $P<0.001$). The rate of using drug-eluting stents (DES) was 97.0% among STEMI patients and 96.9% among NSTEMI, and the details were not different

Table 6. In-Hospital Complications and Mortality of Patients With Diagnosis of STEMI and NSTEMI

	STEMI (n=6,246)	NSTEMI (n=6,710)	P value
Complications	1,553 (24.9)	1,069 (15.9)	<0.001
Cardiogenic shock	747 (12.0)	340 (5.1)	<0.001
Newly developed HF	257 (4.1)	322 (4.8)	0.066
Recurrent ischemia	67 (1.1)	42 (0.6)	0.007
Stent thrombosis	32 (0.5)	10 (0.1)	0.001
Cerebral infarction	36 (0.6)	45 (0.7)	0.570
Cerebral hemorrhage	10 (0.2)	6 (0.1)	0.141
Significant Hb decrease	74 (1.2)	74 (1.1)	0.722
Minor bleeding	188 (3.0)	194 (2.9)	0.728
AV block	187 (3.0)	48 (0.7)	<0.001
VT	341 (5.5)	106 (1.6)	<0.001
VF	183 (2.9)	58 (0.9)	<0.001
Atrial fibrillation	230 (3.7)	195 (2.9)	0.015
Acute kidney injury	56 (0.9)	67 (1.0)	0.612
Sepsis	39 (0.6)	43 (0.6)	0.994
Multi-organ failure	55 (0.9)	39 (0.6)	0.057
In-hospital mortality	316 (5.1)	176 (2.6)	<0.001
Cardiac death	278 (4.5)	137 (2.0)	<0.001
Pump failure	224 (3.6)	111 (1.7)	<0.001
Mechanical complications	25 (0.4)	12 (0.2)	0.022
Arrhythmia	6 (0.1)	6 (0.1)	1.000
Other	23 (0.4)	8 (0.1)	0.001
Non-cardiac death	39 (0.6)	39 (0.6)	0.838
Multi-organ failure	16 (0.3)	15 (0.2)	0.624
Bleeding	5 (0.1)	3 (0.1)	0.868
Sepsis	6 (0.1)	12 (0.2)	0.382
Others	12 (0.2)	9 (0.1)	1.000

Data expressed as number (%). Abbreviations as in Tables 2,3.

between groups. The most common diseased vessel was the left descending artery (46.7%), followed by the right coronary artery (33.7%), left circumflex artery (17.5%), and left main stem (2.3%). Multivessel disease was present in 46.7% of STEMI and 52.1% of NSTEMI patients. During the index procedure, 17.4% of STEMI and 18.2% of NSTEMI patients were examined by intravascular ultrasound.

In-Hospital and Post-Discharge Outcomes

As shown in [Table 6](#), approximately 20% of all patients experienced complications: 24.9% of STEMI and 15.9% of NSTEMI patients. The most common complication was cardiogenic shock (8.4%), followed by newly developed heart failure (4.8%), atrial fibrillation (3.3%), and minor bleeding (3.0%). Overall in-hospital mortality was 3.9%: 5.1% in STEMI and 2.6% in NSTEMI patients. The most common cause of in-hospital death was pump failure (2.6%). After discharge, the median of follow-up period was 525.6 days, and the composite rates of MACE at 6 months, 12 months, and 24 months were 4.4%, 9.6%, and 18.8%, respectively ([Figure](#)). The rates of cardiac death, non-cardiac-death, MI, and repeat PCI at 24 months were 5.2%, 3.4%, 4.5%, and 9.0%, respectively. During 2 years, 6.8% of all patients were readmitted for heart failure.

Discussion

The KAMIR-NIH is an extending and expanding study that is

a successor of the previous KAMIR registry. The KAMIR was developed for the prevention and management of AMI in Korea^{3,6,7} and this interim analysis of the cohort study had some valuable findings of AMI in an Asian population. The Korean patients had different clinical profiles in comparison with those from Western countries. First of all, the proportion of STEMI was still high in Korea. Among Korean AMI patients, STEMI decreased from 56.6% of KAMIR to 48.2% of KAMIR-NIH. Hypertension was the most common risk factor in Korean patients with AMI, as in other registries. Interestingly, compared with the previous KAMIR registry, KAMIR-NIH showed a decrease in the prevalence of smoking in Korea, reflecting a national effort for cessation of smoking over the decade. The prevalence of diabetes mellitus was higher, and the prevalence of dyslipidemia and previous MI was lower than in other countries. On subgroup analysis, NSTEMI patients had higher rates of comorbidities, except smoking. The prevalence of diabetes mellitus has rapidly increased, especially in aging countries.¹⁴ Diabetes mellitus is related to greater endothelial dysfunction,¹⁵ inflammatory processes,¹⁶ and greater atherosclerosis burden, with more diffuse and more multivessel disease.¹⁴ These result in a higher prevalence of multivessel disease, which might be associated with poor prognosis. In contrast, the patients with STEMI were younger than those with NSTEMI, and they less frequently had comorbidities. This discrepancy was consistent with a previous analysis of the KAMIR registry,⁶ and more frequent comorbidities in NSTEMI patients might result from the

A. Kaplan-Meier survival curve for major adverse cardiac events (MACE)

B. Kaplan-Meier survival curve for cardiac death

C. Kaplan-Meier survival curve for repeat percutaneous coronary intervention (PCI)

Figure. Clinical outcomes after discharge. Kaplan-Meier survival curves for (A) major adverse cardiac events (MACE), (B) cardiac death and (C) repeat percutaneous coronary intervention (PCI). CVA, cerebrovascular accident; HF, heart failure.

decrepit old subjects. In addition, NSTEMI would be caused by insidious atherosclerosis rather than sudden interruption of coronary blood flow by plaque rupture, followed by rapid progression of atherothrombosis.⁵ Because our interim analysis demonstrated an increase in NSTEMI, the need for treatment strategies for multivessel disease may be commonly encountered in the current clinical setting.

The KAMIR-NIH showed unique laboratory and echocardiographic findings. Levels of LDL-cholesterol were higher and levels of P2Y12 reaction units (PRU) were lower. As already mentioned, the prevalence of dyslipidemia was lower in this cohort study, compared with other registries. However, the levels of LDL-cholesterol were high in both STEMI and in NSTEMI patients. For secondary prevention after AMI, efforts should be made to lower the level of LDL-cholesterol.¹⁷ The previous guidelines recommend LDL-cholesterol goals of either <70 mg/dl or $\geq 50\%$ reduction from baseline,^{18,19}

or no specific target.²⁰ The previous KAMIR study results supported the strategy of reducing of LDL-cholesterol $\geq 50\%$ from baseline.^{17,21} Recently, the Improved Reduction of Outcomes: Vytarin Efficacy International Trial (IMRPOVE-IT) study proposed that lower is better, and the role of non-statin lipid-lowering agents for improving cardiovascular outcomes.²² In this clinical setting, the newer KAMIR-NIH registry will investigate the target of LDL-cholesterol and the effect of non-statin agents in an Asian population. The previous studies suggested that clopidogrel resistance develops with higher levels of PRU in Korea.^{23,24} Although the mean level of PRU was below the cut-off value for clopidogrel resistance in both STEMI and NSTEMI patients, the newer P2Y12 inhibitors, prasugrel and ticagrelor, were used frequently during hospitalization. In the near future the KAMIR-NIH registry will provide data on antiplatelet agent switching.

In Korea, most patients with AMI undergo coronary

angiography, and are treated by PCI rather than fibrinolysis or coronary artery bypass graft surgery. There are 98 PCI centers in Korea, the population of which is approximately 51 million, and many AMI patients in Korea may have access to the highly experienced PCI centers certificated by the Korean Society of Interventional Cardiology (PCI >100 cases/year). The medical insurance covers the cost of PCI including coronary stents. Therefore, the KAMIR-NIH included almost all angiographic and procedural findings of AMI patients, and the authors are convinced that high-quality data were collected, with a high procedural success rate of 99.4%. Unlike the Western registries, approximately 97% of Korean AMI patients received DES. DES are superior to bare-metal stents in terms of lower rates of target lesion revascularization, but have similar safety outcomes as bare-metal stents.^{7,25,26} The difference between KAMIR-NIH and KAMIR was that only 1% of AMI patients in KAMIR-NIH had 1st-generation DES. Thus, we should focus on 2nd-generation DES or newer DES for real-world practice. In addition, as mentioned before, we found several differences in the characteristics of Korean AMI patients compared with Western populations. The current clinical guidelines for AMI, whether established by a European or American society, are based on Western populations. We propose that new Asian guidelines reflecting these discrepancies are required for the “real world”.

In this study, in-hospital complications and mortality were compared between STEMI and NSTEMI patients. A trend of poor prognosis in STEMI patients was observed. In-hospital mortality was 5.1%, and 24.9% experienced more than 1 periprocedural complications. Because pump failure was the most common cause of cardiac death in both STEMI and NSTEMI patients, it is important to reduce total ischemic time to improve prognosis. After discharge, the rates of MACE, including cardiac death, non-cardiac death, MI, and repeat PCI, continued to be high during 24 months, and a large proportion of the MACE was repeat PCI. The KAMIR score was developed for risk stratification and prediction of 1-year mortality using 6 independent variables: age, Killip class, serum creatinine, in-hospital PCI, left ventricular ejection fraction, and admission glucose.^{27,28} This scoring system should be validated with the newer KAMIR-NIH data, and modified appropriately for prediction of long-term clinical outcomes. Additionally, 6.8% of AMI patients were readmitted for heart failure. The symptoms of heart failure are directly related to quality of life, which may thus need to be included as a subjective factor in the newer risk model for assessment of post-AMI outcomes.²⁹

Study Limitations

First, it is important to control the quality of follow-up data of ongoing prospective cohort studies. Registry data requires high follow-up and response rates to yield reliable data that can be applied in clinical practice. Second, it was difficult to reflect and update the most recent changes in managing AMI during the follow-up period. Third, the authors need to expand and extend the data for improving clinical effect, especially maintaining long-term follow-up.

In conclusion, an interim analysis of the KAMIR-NIH registry revealed that AMI is a still challenging medical problem associated with high in-hospital mortality and poor long-term clinical outcomes in Korea. There are several differences in the clinical profiles, baseline characteristics, risk factors, management and prognosis of AMI patients in Korea in comparison with other Western AMI registries. Therefore, further research into the prevention and management of AMI is

needed for better clinical outcomes, taking into account regional heterogeneity. Ultimately, guidelines for Asian individuals with AMI should be established.

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