Characteristics, In-Hospital and Long-Term Clinical Outcomes of Nonagenarian Compared with Octogenarian Acute Myocardial Infarction Patients

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Received: 27 September 2013
Accepted: 10 February 2014

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This work was supported by a grant of the National Research
Foundation of Korea funded by the Korean Government (MEST),
Republic of Korea (2010-0020261), and by a grant of the Korea
Healthcare Technology R&D Project, Ministry for Health &
Welfare, Republic of Korea (HI12C0275, HI12C0199,
HI13C1527).

We compared clinical characteristics, management, and clinical outcomes of nonagenarian acute myocardial infarction (AMI) patients (n = 270, 92.3 ± 2.3 yr old) with octogenarian AMI patients (n = 2,145, 83.5 ± 2.7 yr old) enrolled in Korean AMI Registry (KAMIR). Nonagenarians were less likely to have hypertension, diabetes and less likely to be prescribed with beta-blockers, statins, and glycoprotein IIb/IIIa inhibitors compared with octogenarians. Although percutaneous coronary intervention (PCI) was preferred in octogenarians than nonagenarians, the success rate of PCI between the two groups was comparable. In-hospital mortality, the composite of in-hospital adverse outcomes and one year mortality were higher in nonagenarians than in octogenarians. However, the composite of the one year major adverse cardiac events (MACEs) was comparable between the two groups without differences in MI or re-PCI rate. PCI improved 1-yr mortality (adjusted hazard ratio [HR], 0.50; 95% confidence interval [CI], 0.36-0.69, $P < 0.001$) and MACEs (adjusted HR, 0.47; 95% CI, 0.37-0.61, $P < 0.001$) without significant complications both in nonagenarians and octogenarians. In conclusion, nonagenarians had similar 1-yr MACEs rates despite of higher in-hospital and 1-yr mortality compared with octogenarian AMI patients. PCI in nonagenarian AMI patients was associated to better 1-yr clinical outcomes.

Keywords: Aged, Eighty and over; Myocardial Infarction; Percutaneous Coronary Intervention

INTRODUCTION

With increased life expectancy, the population of the elderly is increasing, and cardiovascular disease is the major cause of mortality and morbidity in this age group (1). Although age itself is a definite high risk factor in cardiovascular disease adverse outcomes (2), those of extreme chorological age are often excluded from clinical trials of cardiovascular disease (3). Therefore, little is known about the management and outcomes of acute myocardial infarction (AMI) in this age group. Percutaneous coronary intervention (PCI) became pivotal step in the management of AMI. Also, recent advances in technology, procedural techniques, and medical therapy have resulted in improvement in PCI outcomes and enables for the elderly to have an opportunity of PCI. However, risk or benefit of PCI, and long term clinical outcomes in the nonagenarian AMI patients is still controversial. Although current guidelines recommend early coronary revascularization with PCI in patients with AMI, application to nonagenarian AMI patients only might be extrapolated from the data which have analyzed younger AMI patients, because of the paucity of data about nonagenarian AMI patients.

Under this circumstance, we investigated clinical characteristics, management and clinical outcomes in the very elderly AMI patients, especially with nonagenarians compared with relatively younger elderly AMI patients, octogenarians.

MATERIALS AND METHODS

Study population

Consecutive 14,885 patients enrolled in the Korea Acute Myocardial Infarction Registry (KAMIR; November 2005 to December 2007). A total of 2,415 AMI patients who were older than 80 yr old consisted of the study population. They were divided to two groups according to age (Nonagenarians; n = 270, Octogenarians; n = 2,145). The eligible patients were ≥ 80 yr old at admission (Nonagenarians, 90 to 99 yr old; octogenarians, 80 to 89 yr old), had suggestive symptoms with or without ST elevation > 2 mm in ≥ 2 precordial leads, ST elevation > 1 mm in ≥ 2 limb leads, or new left bundle branch block on the 12-lead electrocardiogram with a concomitant increases of at least one cardiac enzyme. The criteria for exclusion included malignant neoplasm, leukemia, lymphoma, and metastatic solid tumors. Clinical characteristics and in-hospital clinical outcomes were analyzed in all 2,415 eligible AMI patients. One year clinical outcomes were analyzed in 2,089 patients who survived at hospital discharge.

The KAMIR, launched in November 2005, is a Korean prospective multicenter data collection registry reflecting real-world treatment practices and outcomes in Asian patients diagnosed with AMI. The registry includes 50 community and teaching hospitals with facilities for primary PCI and on-site cardiac surgery. Data were collected by a trained study coordinator using a standardized case report form and protocol. The study protocol was approved by the ethics committee at each participating institution. All patients gave written informed consent.

Study definition and end points

AMI was diagnosed by the presence of characteristic clinical presentation, serial changes on electrocardiogram suggesting infarction, and increases in cardiac enzymes. Cardiogenic shock was as systolic blood pressure < 90 mmHg with the evidence of tissue hypoperfusion. Atrioventricular (AV) block needing pacing was defined as the case which demonstrated higher than second degree AV bock needing temporary or permanent pacing. Cerebrovascular accident (CVA) was defined as a new focal neurologic defect with the proof of brain image. New onset heart failure was defined as newly developed New Yolk Heart Association class III/IV dyspnea, orthopnea, rales greater than one-third lung fields, elevated jugular venous pressure, or pulmonary congestion on chest radiograph thought to be related to cardiac dysfunction. Major bleeding was defined as an absolute hematocrit drop of ≥ 15%, any intracranial bleeding, bleeding events associated with causing death, the need for surgery, or transfusion, or any clinically relevant bleeding, as judged by the investigator. Minor bleeding was defined as any other bleeding which did not meet the major bleeding criteria, including vascular access complication.

During the in-hospital period, patients received medical treatment including beta blockers, angiotensin converting enzyme inhibitors or angiotensin receptor blockers and statins. After discharge, the patients continued receiving the same kinds of medications that they received in hospital period except some intravenous or temporary medications.

The composite of in-hospital adverse outcomes was defined as the composite of death, cardiogenic shock, AV block needing pacing, new onset atrial fibrillation, fatal arrhythmia, CVA, new onset heart failure, major bleeding or minor bleeding. The primary end point was the composite of major adverse cardiac events (MACEs) during the 12 months of clinical follow-up. MACEs was defined as the composite of all-cause death, MI, and repeated PCI or coronary artery bypass grafting (CABG). All-cause deaths were considered cardiac death unless a noncardiac death could be defined clearly. Recurrent MI was defined as recurrent symptoms with new electrocardiographic changes compatible with MI or cardiac markers at least twice the upper limit of normal. Target-vessel revascularization (TVR) was defined as any repeated intervention driven by the lesions located in the treated vessel within and beyond the target limits.

Statistical analysis

All statistical analyses were done with SPSS 18.0 (Statistical Package for the Social Sciences, SPSS-PC Inc., Chicago, IL, USA). For continuous variables, differences between groups were evaluated by an unpaired t-test or Mann-Whitney rank-sum test. For discrete variables, differences were expressed as counts and percentages, and were analyzed with a chi-square test (or Fisher's extract) between groups as appropriate. We constructed Kaplan-Meier curves to the composite of the primary end point, as well as all cause death, cardiac death, and repeated PCI. The differences between the groups were assessed by log-rank test. A propensity score for performing PCI was calculated to adjust potential confounders using a logistic regression model. All available variables considered potentially relevant were included: gender, hypertension, diabetes mellitus, dyslipidemia, smoking, family history of coronary heart disease, previous history of angina, MI, PCI, CABG, chronic kidney disease (CKD), CVA, peripheral vascular disease, heart failure, Killip class on presentation, and left ventricular ejection fraction. Cox proportional hazards regression was used to compute hazard ratio (HR) as estimates for each end point. The HRs were adjusted for propensity score and concomitant medications. The predicted accuracy of the logistic model was assessed using the area under the receiver operating characteristic curve (c statistic), which was 0.720. All analyses were 2-tailed, with clinical significance defined as values of $P < 0.05$.

Ethics statements

The study was conducted according to the Declaration of Hel-

sinki. The institutional review board of all paticipating centers approved the study protocol. The approval number was I-2008--1-009 of Chonnam National University Hospital. Written informed consent was obtained from all participating patients.

RESULTS

Baseline clinical characteristics

Mean age of nonagenarians were 92.3 ± 2.3 yr old, whereas that of octogenarians were 83.5 ± 2.7 yr old. Vital sign at hospital admission were not different between the 2 groups. More octoge-

narians complained typical chest pain (75.8% vs 68.9%, P = 0.013), whereas more nonagenarians complained dyspnea (45.5% vs 38.9%, P = 0.038) and nonagenarians had higher Killip classification (≥ 3 on presentation: 31.2% vs 21.6%, P = 0.001). Nonagenarians were less likely to have hypertension (46.7% vs 57.5%, P = 0.001), diabetes (15.6% vs 27.9%, P < 0.001) compared with octogenarians. No significant differences in other previous medical history were found between the 2 groups except that nonagenarians had higher incidence of past history of heart failure. Also, left ventricular systolic function in nonagenarians was lower than that of octogenarian (45.0% vs 49.0%, P < 0.001). Labo-

Table 1. Baseline clinical characteristics

Characteristics	Nonagenarians (n = 270)	Octogenarians (n = 2,145)	P value
Male gender, n (%)*	157 (58.7)	1,180 (55.1)	0.336
Age (yr)†	92.3 ± 2.3	83.5 ± 2.7	< 0.001
Vital sign†			
Systolic blood pressure (mmHg)	126.6 ± 30.1	126.0 ± 30.9	0.784
Diastolic blood pressure (mmHg)	76.2 ± 16.6	75.2 ± 17.5	0.981
Heart rate (/min)	81.9 ± 22.7	79.7 ± 30.1	0.246
Subjective symptom*			
Typical symptom	182 (68.9)	1,593 (75.8)	0.013
Dyspnea	121 (45.5)	822 (38.9)	0.038
Medical history, n (%)*			
Hypertension	126 (46.7)	1,233 (57.5)	0.001
Diabetes mellitus	42 (15.6)	598 (27.9)	< 0.001
Dyslipidemia	9 (3.3)	123 (5.7)	0.102
Smoking	98 (36.3)	759 (35.4)	0.768
Previous history of MI	16 (5.9)	114 (5.3)	0.675
Previous history of PCI	10 (3.7)	112 (5.2)	0.283
Previous CABG	0 (0)	20 (0.9)	0.156
Previous history of CVA	23 (8.5)	236 (11.0)	0.214
Previous history of PVD	2 (0.7)	41 (1.9)	0.224
Previous history of CKD	11 (4.1)	59 (2.8)	0.222
Previous history of heart failure	25 (9.3)	120 (5.6)	0.017
Killip class ≥ III on presentation*	79 (31.2)	442 (21.6)	0.001
Left ventricular ejection fraction (%)‡	45.0 (35.3-55.0)	49.0 (40.0-58.0)	< 0.001
Laboratory finding‡			
Peak troponin-I (ng/mL)	10.4 (2.5-36.7)	13.3 (3.1-43.2)	0.202
Low density lipoprotein-C (mg/dL)	95.0 (74.0-129.0)	109.0 (86.0-132.0)	0.001
Serum creatinine (mg/dL)	1.1 (0.9-1.4)	1.1 (0.9-1.4)	0.085
High sensitivity C-reactive protein (mg/dL)	2.0 (0.3-8.5)	1.5 (0.3-7.0)	0.141
N-terminal pro-brain natriuretic peptide (pg/mL)	1,667.0 (569.5-6,588.5)	1,273.5 (316.0-4,472.0)	0.056
Diagnosis, n (%)*			0.167
ST-segment elevation MI	155 (58.7)	1,150 (54.2)	
Non-ST-segment elevation MI	109 (41.3)	971 (45.8)	
In-hospital medication, n (%)*			
Aspirin	254 (94.1)	2,066 (96.3)	0.074
Clopidogrel	246 (91.1)	2,012 (93.8)	0.091
Beta-blocker	162 (60.0)	1,487 (69.3)	0.002
ACEI/ARB	215 (79.6)	1,750 (81.6)	0.437
Statin	177 (65.6)	1,538 (71.7)	0.036
Glycoprotein IIb/IIIa inhibitors	14 (5.2)	233 (10.9)	0.004
Discharge medication, n (%)*	(n = 225)	(n = 1,864)	
Aspirin	218 (96.9)	1,840 (98.7)	0.057
Clopidogrel	210 (93.3)	1,799 (96.5)	0.019
Beta-blocker	151 (67.1)	1,398 (75.0)	0.011
ACEI/ARB	197 (87.6)	1,635 (87.7)	0.945
Statin	158 (70.2)	1,428 (76.6)	0.034

*Comparison made using chi-square test; †Mean (standard deviation); comparison made using t-test; ‡Median (25% to 75% percentiles); comparison made using Mann-Whitney test. CABG, coronary artery bypass grafting; CKD, chronic kidney disease; CVA, cerebrovascular accidents; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease.

ratory findings were comparable between the groups except that serum level of low density lipoprotein-cholesterol was higher in octogenarians. The use beta-blockers, statins and glycoprotein IIb/IIIa inhibitors were lower in nonagenarians during admission. The use of clopidogrel, beta-blockers, and statins were lower in nonagenarians at discharge (Table 1).

Procedural characteristics

A total of 1,682 (70.1%) patients underwent PCI, which was more commonly undergone in octogenarians than nonagenarians (71.7% vs 57.2%, $P < 0.001$). However, the success rate of PCI was comparable in both groups (96.7% vs 96.8%, $P = 0.984$). Patients who underwent PCI presented more typical chest pain (81.4% vs 60.2%, $P < 0.001$), and less dyspnea (34.3% vs 51.7%, $P < 0.001$). Patients who did not undergo PCI had higher prevalence of past history of MI, PCI, CVA, CKD, heart failure, high Killip class (≥ 3 on presentation), and more presented as non ST-segment elevation MI (NSTEMI) (Table 2). In patients with STEMI, 244 (18.8%) patients did not underwent PCI. 19 (1.5%) patients refused PCI, whereas 117 (9.0%) patients were not indicated or poor candidate for PCI decided by physicians.

Analysis of angiographic findings showed no differences in location of culprit lesions, prevalence of multi-vessel disease, American College of Cardiology/American Heart Association (ACC/AHA) lesion type, distribution of pre- and post-proce-

dural Thrombolysis In Myocardial Infarction (TIMI) flow grade, stent type, length, and stent diameter between the nonagenarians and octogenarians (Table 3).

In-hospital outcomes

Compared with octogenarians, nonagenarians had higher death rate during hospitalization (15.7% vs 11.4%, $P = 0.041$), and the composite of in-hospital adverse outcomes (26.3% vs 20.0%, $P = 0.017$). These differences were persisted even after adjustment for potential confounding factors with adjusted hazard ratio (HR) of 1.68 (95% confidence interval [CI], 1.11-2.52; $P = 0.013$) for death, and 1.56 (95% CI, 1.13-2.15; $P = 0.007$) for the composite of in-hospital averse outcomes. However, the individual risk for cardiogenic shock, AV block needing pacing, fatal arrhthmia, new onset CVA, new onset heart failure, minor bleeding, major bleeding were compatible between the 2 groups, and also similar between the 2 groups after adjustment (Table 4). PCI did not reduce in-hospital mortality and the composite of in-hospital adverse outcomes both in nonagenarians and octogenarians (Fig. 1).

One year clinical outcomes

During the 12 month follow-up period, a primary end point event occurred in 24.6% of nonagenarians and 22.2% of octoge-

Table 2. Baseline clinical characteristics according to PCI

Parameters	Non-PCI group (n = 718)	PCI group (n = 1,682)	P value
Nonagenarians, n (%)*	115 (16.0)	154 (9.2)	< 0.001
Male gender, n (%)*	415 (57.9)	914 (54.3)	0.110
Vital sign†			
Systolic blood pressure (mmHg)	129.1 ± 32.0	124.8 ± 30.2	0.002
Diastolic blood pressure (mmHg)	76.1 ± 17.8	75.0 ± 17.2	0.149
Subjective symptom*			
Typical symptom	415 (60.2)	1,355 (81.4)	< 0.001
Dyspnea	365 (51.7)	570 (34.3)	< 0.001
Medical history, n (%)*			
Hypertension	411 (57.2)	942 (56.0)	0.576
Diabetes mellitus	203 (28.3)	436 (25.9)	0.233
Dyslipidemia	48 (6.7)	84 (5.0)	0.096
Smoking	243 (33.8)	613 (36.4)	0.223
Previous history of MI	62 (8.6)	66 (3.9)	< 0.001
Previous history of PCI	47 (6.5)	75 (4.5)	0.033
Previous CABG	12 (1.7)	8 (0.5)	0.003
Previous history of CVA	99 (13.8)	157 (9.3)	0.001
Previous history of PVD	13 (1.8)	30 (1.8)	0.964
Previous history of CKD	35 (4.9)	34 (2.0)	< 0.001
Previous history of heart failure	81 (11.3)	63 (3.7)	< 0.001
Killip class ≥ III on presentation*	226 (33.7)	293 (18.1)	< 0.001
Left ventricular ejection fraction (%)	45.9 ± 13.9	49.6 ± 12.8	< 0.001
Diagnosis, n (%)*			< 0.001
ST-segment elevation MI	244 (18.8)	1,057 (81.2)	
Non-ST-segment elevation MI	465 (43.1)	614 (56.9)	

*Comparison made using chi-square test; †Mean (standard deviation), comparison made using t-test. CABG, coronary artery bypass grafting; CKD, chronic kidney disease; CVA, cerebrovascular accidents; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease.

Table 3. Procedural characteristics

| Procedures	Nonagenarians (n = 270)	Octogenarians (n = 2,145)	P value
Location of culprit lesion, n (%)			
Left anterior descending artery	83 (50.0)	778 (46.0)	0.328
Left circumflex artery	14 (8.4)	257 (15.2)	0.018
Right coronary artery	63 (38.0)	615 (36.4)	0.690
Left main coronary artery	6 (3.6)	40 (2.4)	0.324
Multi-vessel disease, n (%)	107 (63.7)	1,110 (65.5)	0.641
ACC/AHA Lesion types, n (%)			
A	7 (4.5)	65 (4.2)	0.846
B1	20 (12.8)	267 (17.1)	0.173
B2	39 (25.0)	418 (26.8)	0.635
C	90 (57.7)	812 (52.0)	0.173
B2/C	129 (82.7)	1,230 (78.7)	0.248
Preprocedural TIMI flow grade, n (%)			
0	88 (54.3)	696 (43.3)	0.007
1	13 (8.0)	212 (13.2)	0.060
2	19 (11.7)	258 (16.1)	0.149
3	42 (25.9)	441 (27.4)	0.680
Stent type			0.029
Bare-metal stents	21 (15.2)	129 (9.4)	
Drug-eluting stents	117 (84.8)	1,246 (90.6)	
Stent length (mm)	25.1 ± 6.3	25.0 ± 6.0	0.799
Stent diameter (mm)	3.1 ± 0.4	3.1 ± 0.4	0.356
No. of stents	1.6 ± 0.9	1.5 ± 0.8	0.358
Postprocedural TIMI flow grade, n (%)			
0	5 (3.3)	49 (3.2)	0.974
1	6 (3.9)	24 (1.6)	0.049
2	14 (9.2)	114 (7.5)	0.461
2	128 (83.7)	1,335 (87.7)	0.151

ACC/AHA, American College of Cardiology/American Heart Association; TIMI, Thrombolysis In Myocardial Infarction.

Table 4. In-hospital outcomes

Outcomes	Nonagenarians (n = 270)	Octogenarians (n = 2,145)	Unadjusted HR (95% CI)	P value	Adjusted HR (95% CI)	P value
All cause Death (%)	15.7	11.4	1.45 (1.02-2.07)	0.041	1.68 (1.11-2.52)	0.013
Cardiac death (%)	12.4	9.1	1.42 (0.96-2.10)	0.083	1.51 (0.95-2.40)	0.083
Cardiogenic Shock (%)	11.5	8.4	1.42 (0.95-2.12)	0.092	1.32 (0.82-2.13)	0.255
AV block* (%)	3.7	2.9	1.29 (0.65-2.55)	0.460	1.34 (0.64-2.77)	0.437
Fatal arrhythmia (%)	4.8	4.7	1.03 (0.57-1.87)	0.911	1.12 (0.57-2.23)	0.742
CVA (%)	0.7	0.9	0.79 (0.18-3.41)	0.755	0.87 (0.20-3.87)	0.859
New onset HF (%)	1.1	1.4	0.82 (0.25-2.71)	0.745	0.62 (0.14-2.64)	0.513
Minor bleeding (%)	0.7	0.3	2.28 (0.47-11.03)	0.306	4.28 (0.78-23.37)	0.093
Major Bleeding (%)	0.7	0.7	1.14 (0.26-5.03)	0.867	1.67 (0.35-7.89)	0.517
Any adverse outcomes (%)[†]	26.3	20.0	1.42 (1.06-1.90)	0.017	1.56 (1.13-2.15)	0.007

*AV block, atrioventricular block needing pacing; [†]any adverse outcomes, death, cardiogenic shock, AV block needing pacing, new onset atrial fibrillation, fatal arrhythmia, cerebrovascular accidents, new onset heart failure, minor bleeding, or major bleeding. CI, confidence interval; CVA, cerebrovascular accidents; HF, heart failure; HR, hazard ratio.
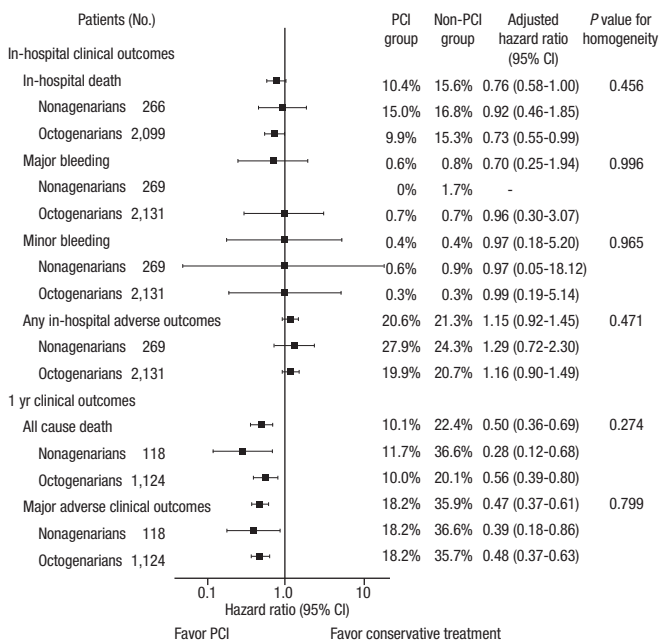
Fig. 1. Estimates of the clinical outcomes according to percutaneous coronary intervention (PCI).

narians (log-rank P = 0.759; Fig. 2A). Adjustment for propensity score, and treatment parameters also showed no difference in the primary end point between the 2 groups (HR, 1.25; 95% CI, 0.62-2.51; P = 0.528; Table 5). Outcomes for the selected end points are shown in Table 5. Compared with octogenarians, nonagenarians had significantly higher all cause death rate (20.3% vs 12.2%, log-rank P = 0.032; Fig. 2B). However, this difference disappeared after adjustment. Cardiac death occurred in 13.6% of nonagenarians, and in 8.1% of octogenarians (Fig. 2C). MI occurred in 0.8% of nonagenarians, and in 3.0% of octogenarians. Repeated PCI occurred in 4.2% of nonagenarians, and in 5.7% of octogenarians (Fig. 2D). Adjusted HR for cardiac death, MI, repeated PCI were not different between the 2 groups. PCI reduced the primary end point (HR, 0.47; 95% CI, 0.37-0.61; P < 0.001) and 1-yr all cause death (HR, 0.50; 95% CI, 0.36-0.69; P < 0.001) both in nonagenarians and octogenarians (Fig. 1).
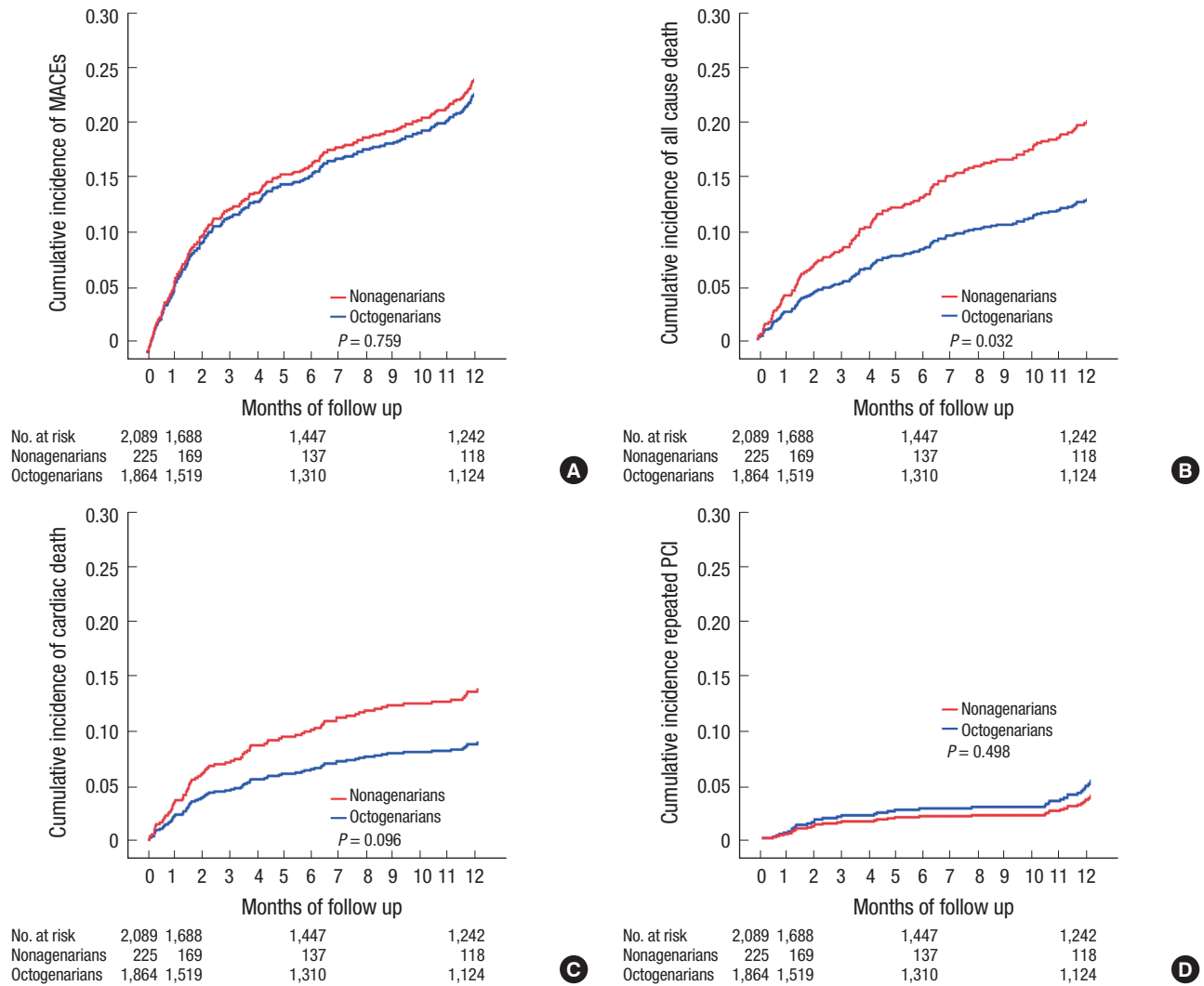
Clinical outcomes according to the diagnosis of ST-segment elevation myocardial infarction and non ST-segment elevation myocardial infarction

In nonagenarians, patients with STEMI had significantly higher in-hospital cardiac death rate than patients with NSTEMI (16.1% vs 7.3%, P = 0.033) without differences in the rates of in-hospital all-cause death, and 1-yr all-cause death, MI, repeated PCI, CABG and MACEs.

In octogenarians, patients with STEMI had significantly higher in-hospital cardiac (11.8% vs 5.7%, P < 0.001) and all-cause death rate (14.4% vs 7.8%, P < 0.001) than patients with NSTEMI. In 1-yr clinical outcomes, patients with NSTEMI had significantly higher MI (1.7% vs 4.6%, log-rank P = 0.002) and total MACE rates (19.7% vs 25.0%, log-rank P = 0.019) than patients with STEMI without differences in the rates of all-cause death, repeated PCI and CABG (Table 6).

DISCUSSION

The elderly constitute an increasing segment of the population and cardiovascular disease is highly prevalent among them, accounting for most of their morbidity and mortality (1). The elderly carries higher prevalence of cardiovascular morbidities such as diabetes mellitus, hypertension and mortalities, which rank the leading cause of death among them (4-7). Approximately one third of the elderly die as a direct consequence of coronary atherosclerosis (8). Especially, AMI in the elderly might be quite lethal to them. However, there is little known about the management, clinical outcomes according to the initial management in the very elderly AMI patients, because most of clinical trials were based on relatively younger patients, and the population of the very elderly AMI patients constitute very small portion. Furthermore, there have been few reports regarding nonagenarian AMI patients. Although both octogenarian and nonagenarian AMI patients were considered as the very elderly population, there might be differences between the two groups, and even physicians might approach to them with different treatment attitude. Therefore, the present study compared clinical

Fig. 2. Estimates of the clinical outcomes according to age group. (**A**) Cumulative incidence of major adverse cardiac events (MACEs). (**B**) Cumulative incidence of all cause death. (**C**) Cumulative incidence of cardiac death. (**D**) Cumulative incidence of repeated percutaneous coronary intervention (PCI).

Table 5. Estimated hazard ratio for individual components of the primary endpoints

Adverse events	Nonagenarians (n = 118)	Octogenarians (n = 1,124)	Unadjusted HR (95% CI)	P value	Adjusted HR (95% CI)	P value
Total MACEs (%)	24.6	22.2	1.06 (0.72-1.57)	0.760	1.25 (0.62-2.51)	0.528
All cause death (%)	20.3	12.2	1.61 (1.04-2.51)	0.034	1.26 (0.61-2.58)	0.535
Cardiac death (%)	13.6	8.1	1.58 (0.92-2.73)	0.100	1.57 (0.68-3.58)	0.288
MI (%)	0.8	3.0	0.28 (0.04-2.04)	0.208	0.57 (0.07-4.51)	0.596
Repeated PCI (%)	4.2	5.7	0.73 (0.30-1.82)	0.503	0.62 (0.22-1.75)	0.360
TVR (%)	3.4	3.5	0.96 (0.34-2.69)	0.939	0.75 (0.22-2.51)	0.640
CABG (%)	0	2.2	0.04 (0.00-15.22)	0.293	0	0.980

CABG, coronary artery bypass grafting; CI, confidence interval; HR, hazard ratio; MACE, major adverse cardiac events; MI, myocardial infarction; PCI, percutaneous coronary intervention; TVR, target vessel revascularization.

characteristics, management, and long term outcomes between nonagenarian and octogenarian AMI patients in the contemporary PCI era.

Nonagenarians or centenarians present different clinical characteristics compared with younger elderly populations (9). In the present study, nonagenarian AMI patients were less likely to have hypertension and diabetes compared with octogenarian AMI patients. This may partially explain successful aging in nonagenarians. However, in-hospital mortality and adverse clinical outcomes were higher in nonagenarian AMI patients compared with octogenarian AMI patients. These might be attributable to the special physiologic and functional status of

Table 6. Clinical outcomes according to the diagnosis of ST-segment elevation myocardial infarction and non ST-segment elevation myocardial infarction

Outcomes	Nonagenarian			Octogenarian		
	STEMI	NSTEMI	P value	STEMI	NSTEMI	P value
In-hospital clinical outcomes	(n = 155)	(n = 109)		(n = 1,150)	(n = 971)	
In-hospital death (%)	19.5	11.0	0.065*	14.4	7.8	< 0.001*
In-hospital cardiac death (%)	16.1	7.3	0.033*	11.8	5.7	< 0.001*
1-yr clinical outcomes	(n = 124)	(n = 97)		(n = 973)	(n = 884)	
Total MACEs (%)	21.4	29.8	0.217[†]	19.7	25.0	0.019[†]
All cause death (%)	17.1	25.5	0.178[†]	10.9	13.7	0.131[†]
Cardiac death (%)	11.4	17.0	0.245[†]	7.0	9.4	0.110[†]
MI (%)	1.4	0	0.430[†]	1.7	4.6	0.002[†]
Repeated PCI (%)	4.3	4.3	0.905[†]	6.3	5.0	0.554[†]
TVR (%)	4.3	2.1	0.602[†]	3.8	3.1	0.694[†]
CABG (%)	0	0		1.5	3.1	0.069[†]

*Comparison made using chi-square test; [†]Comparison made using log-rank test. CABG, coronary artery bypass grafting; MACE, major adverse cardiac events; MI, myocardial infarction; NSTEMI, non ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction; TVR, target vessel revascularization.

very old people. With increasing age, they have weaker physiologic and functional status, and are prone to develop complications by cardiovascular medications. This might limit clinicians to use all recommended cardiovascular medications in nonagenarian AMI patients.

Although advanced age is not the contraindication of PCI in patients with AMI, current guidelines describe that the elderly are at increased risk from coronary revascularization procedures, and that is usually quite challengeable to interventionists because of peri-procedural comorbidities and complications accompanying with extreme old age (10). In the present study, PCI did not increase any in-hospital adverse outcomes including minor bleeding, and major bleeding both in nonagenarians and octogenarians. Also, PCI success rate was 96.7% in octogenarians, 96.8% in nonagenarians, which were similar to that of previous reports in Korea which analyzed AMI patients in all range of age (11-14). That was even higher than previous reports (15-19). From et al. reported nonagenarian PCI success rate as 91% in 2008 (19). The growing interest in PCI, advances in technology and procedural techniques might contribute to the improved PCI success rate in the contemporary era. Also, repeated PCI rate were not different between nonagenarian and octogenarians AMI patients. Nonetheless, in patients with STEMI, 244 (18.8%) patients did not undergo PCI in the present study. Furthermore, 117 (9.0%) patients were frustrated PCI by physicians' decision, while 19 (1.5%) patients refused PCI, 51 (3.9%) patients were planned to perform CABG, and 57 (4.4%) patients underwent thrombolysis. It might involve physicians' bias or patient preference, and exaggerated perceived bleeding risk by extreme old age. The present study showed that the elderly could get comparable PCI success rate, if they did not have contraindication undergoing PCI. These findings suggest that PCI should not be frustrated only because of old age.

The elderly have known to have more complex coronary lesions (20-22). In the present study, almost 80% of both nonagenarians and octogenarians have ACC/AHA lesion type B2 or C.

Also, almost 65% of both nonagenarians and octogenarians have multivessel disease. However, there were no significant differences in angiographic findings between nonagenarians and octogenarians. Furthermore, PCI success rate and achieving post-procedural TIMI flow grade 3 were similar. These result might suggest that PCI in nonagenarian AMI patients is not much difficult technically compared with PCI in octogenarian AMI patients.

The present study showed that PCI both in nonagenarian and octogenarian AMI patients was associated to better outcomes. Although PCI improved in-hospital death only in octogenarians, it improved 1 yr MACEs without increasing complications both in octogenarians and nonagenarians. Major or minor bleeding rate of PCI group was also comparable with that of non-PCI group. This was consistent with the CRUSADE trial which reported that early coronary revascularization improved in-hospital mortality over more than 5,000 nonagenarian NSTEMI-acute coronary syndrome patients (10). From et al. also reported PCI in nonagenarian patients improved in-hospital mortality and MACEs (19). Long term survival of nonagenarians was similar to age- and gender-matched control subjects during median 3.6 yr follow-up. However, none of the previous studies analyzed the efficacy of PCI in nonagenarian AMI patients more than 1 yr follow-up duration. The present study added the evidence of beneficial effect of PCI in the management of elderly AMI patients.

The present study has several limitations. First, management strategy was left to the discretion of the operators. They might regard the general physiologic status as the higher risk profiles than chronogical age. Therefore, there might be a selection bias for PCI in favor of lower risk rather than chronological age. Second, the present study did not compare the relatively elderly AMI patients (i.e. septuagenarians) and the extreme old age AMI patients (i.e. octogenarians or nonagenarians). Therefore, it was hard to evaluate risk/benefit ratio of PCI according to selected age group. Third, all-cause death was defined as cardiac

death a non-cardiac death could be defined clearly. Lots of mortality causes of very old patients include frailty, terminal disease, and organ failures, and sudden death. Therefore, some patients designated as having cardiac death might have non-cardiac cause of death actually. Fourth, the present study was analyzed retrospectively. The non-randomized nature of the registry data could have resulted in selection bias. Although most confounders were included in the multivariate regression analysis, it is possible that some potential bias were included. Large scale prospective randomized study is needed to clarify the benefits of PCI in the verly elderly AMI patients. Nonetheless, the present study have strengths in that non-randomized design of this study included many patients who would not have been enrolled in randomized trials, including those with severe comorbidities. Also the present study had strengths in that the study represented real world management trends in the very elderly AMI patients, not limited to the patients undergoing PCI like as most of other studies.

DISCLOSURE

APPENDIX

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