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ORIGINAL ARTICLE
Ischemic Heart Disease

Early Invasive Strategy for Octogenarians and Nonagenarians With Acute Myocardial Infarction

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Background: Older adults with acute myocardial infarction (AMI) are currently a rapidly growing population. However, their clinical presentation and outcomes remain unresolved.

Methods and Results: A total of 268 consecutive AMI patients were analyzed for clinical characteristics and outcomes with major adverse cardiovascular events (MACE) and all-cause mortality within 1 year. Patients aged ≥80 years (Over-80; n=100) were compared with those aged ≤79 years (Under-79; n=168). (1) Primary percutaneous coronary intervention (PCI) was frequently and similarly performed in both the Over-80 group and the Under-79 group (86% vs. 89%; P=0.52). (2) Killip class III–IV (P<0.01), in-hospital mortality (P<0.01), MACE (P=0.03) and all-cause mortality (P<0.01) were more prevalent in the Over-80 group than in the Under-79 group. (3) In the Over-80 group, frail patients showed a significantly worse clinical outcome compared with non-frail patients. (4) Multivariate analysis revealed Killip class III–IV was associated with MACE (odds ratio [OR]=3.51; P=0.02) and all-cause mortality (OR=9.49; P<0.01) in the Over-80 group. PCI was inversely associated with all-cause mortality (OR=0.13; P=0.02) in the Over-80 group.

Conclusions: The rate of primary PCI did not decline with age. Although octogenarians/nonagenarians showed more severe clinical presentation and worse short-term outcomes compared with younger patients, particularly in those with frailty, the prognosis may be improved by early invasive strategy even in these very old patients.

Key Words: Acute myocardial infarction; Early invasive strategy; Frailty; Octogenarians/Nonagenarians; Outcomes

Because of the aging of society, very old adults with acute myocardial infarction (AMI) are a rapidly growing proportion of the population. According to intensive care unit registries, older adult patients aged ≥75 years constitute approximately 30–40% of all hospitalized patients with AMI.[1–3] Primary percutaneous coronary intervention (PCI) is currently the treatment of choice for patients presenting with ST-segment elevation myocardial infarction (STEMI)[4–6] and for those with non-STEMI (NSTEMI).[4,7] However, the value of an early invasive strategy in older adult patients is not well established because older patients, particularly octogenarians and nonagenarians, have either been excluded or rarely enrolled in large clinical trials.[8–11] Moreover, octogenarians and nonagenarians are significantly less likely to undergo emergency coronary angiography (CAG) and PCI after AMI compared with younger patients. Only 32.2% of patients with STEMI aged ≥85 years received primary PCI compared with 52.1% of patients aged ≤55 years.[12] Also, 38% of patients with NSTEMI who are aged ≥81 years received emergency CAG compared with 78% of those aged ≤60 years.[13] Although recent reports suggest that the use of primary PCI is improving and that treatment gap disparities are lessening in older adult patients with AMI,[14–18] further studies of how to best triage octogenarians and nonagenarians are warranted.

The care of older adult patients in AMI is also complicated by the complexity of geriatric syndrome. Frailty is best known as a geriatric syndrome of impaired resilience to stressors, which confers a high risk for adverse

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Table 1. Clinical Characteristics

	All (n=268)	Over-80 (n=100)	Under-79 (n=168)	P value
Age (years)	75 [65–83]	84 [82–90]	69 [61–73]	–
Male	194 (72)	55 (55)	139 (83)	<0.01
STEMI	167 (62)	61 (61)	106 (63)	0.73
Killip class III–IV	71 (26)	35 (35)	36 (21)	<0.01
CPA on arrival	16 (6)	5 (5)	11 (7)	0.61
Onset to door (min)	144 [74–277]	146 [74–266]	140 [70–275]	0.81
Door to balloon (min)	96 [64–237]	117 [62–221]	88 [62–245]	0.20
Laboratory findings				
Hb (g/dL)	13.7 [11.9–15.1]	12.7 [11.3–13.7]	14.6 [12.9–15.6]	<0.01
Creatinine (mg/dL)	0.79 [0.67–1.09]	0.95 [0.66–1.29]	0.77 [0.67–0.94]	0.03
AST (U/L)	35 [24–64]	42 [27–104]	31 [22–54]	<0.01
ALT (U/L)	24 [16–41]	22 [14–36]	25 [17–43]	0.13
LDH (U/L)	247 [200–341]	288 [217–412]	229 [194–296]	<0.01
hs-cTnT (ng/mL)	0.151 [0.043–0.69]	0.265 [0.112–0.935]	0.085 [0.003–0.466]	<0.01
CPK (U/L)	164 [107–398]	188 [107–471]	158 [107–385]	0.47
CK-MB (U/L)	19 [12–38]	23 [15–37]	17 [11–38]	0.02
Peak CPK (U/L)	1,007 [400–2,747]	885 [377–2,411]	1,201 [410–3,029]	0.17
Peak CK-MB (U/L)	97 [38–265]	78 [38–247]	108 [34–266]	0.71
BNP (pg/mL)	145 [43–578]	442 [120–907]	83 [24–266]	<0.01

Unless indicated otherwise, data are presented as median [interquartile range] or n (%). ALT, alanine aminotransferase; AST, aspartate aminotransferase; BNP, brain natriuretic peptide; CK-MB, creatinine kinase-MB; CPA, cardiopulmonary arrest; CPK, creatine phosphokinase; Hb, hemoglobin; hs-cTnT, high-sensitivity cardiac troponin T; LDH, lactase dehydrogenase; Over-80, patients aged ≥80 years; STEMI, ST elevation myocardial infarction; Under-79, patients aged ≤79 years.

outcomes.[19,20] The prognostic value of frailty in older adult patients with AMI receiving primary PCI has not been well evaluated.

Therefore, the present study aimed to evaluate the rate of primary PCI in octogenarians and nonagenarians relative to their younger counterparts. We also sought to assess whether a short-term survival benefit can be achieved by early invasive management in these very old patients. In addition, the significance of frailty in octogenarians and nonagenarians receiving primary PCI was evaluated in relation to their outcomes.

Methods

Study Design and Patients

This study was a retrospective single-center observational study that consecutively enrolled 268 patients with AMI who were admitted to Chikamori Hospital between January 2020 and August 2021. The inclusion criteria were: (1) STEMI, defined by persistent chest discomfort or other symptoms suggestive of ischemia and ST-segment elevation in at least 2 contiguous leads; (2) NSTEMI, defined by symptoms consistent with acute myocardial ischemia, absence of persistent ST-segment elevation, and elevation of high-sensitivity cardiac troponin T (>99th percentile upper reference limit; >0.014 ng/mL). The therapeutic strategy and the decision to perform coronary revascularization and mechanical circulatory support (MCS) were at the discretion of the attending cardiologist according to the guidelines.

Definition and Endpoints

We assessed two groups of patients: those aged ≥80 years (Over-80), and those aged ≤79 years (Under-79), and analyzed these AMI patients for clinical presentation and outcomes. The severity of heart failure (HF) was assessed at admission based on the Killip classification; Killip class III–IV was defined as severe HF. The severity of valvular heart disease was assessed using transthoracic echocardiogram performed on admission; only those with moderate or severe severity were defined as valvular heart disease. The severity of coronary artery disease was assessed using the number of coronary artery lesions and Thrombolysis in Myocardial Infarction (TIMI) flow grade of CAG findings performed at or after admission. To assess frailty, the Clinical Frailty Scale (CFS) was used as it provides a generally accepted clinical definition of frailty.[21,22] The CFS ranged from 1 (very fit) to 9 (terminally ill). The CFS results were categorised into two groups: non-frail (CFS 1–4), and frail (CFS 5–9).

The primary outcomes of the study were in-hospital death and all-cause death within 1 year, as well as major adverse cardiac events (MACE), which included a composite of all-cause death, non-fatal myocardial infarction, and non-fatal stroke.

Statistical Analysis

Categorical variables are presented as frequencies and percentages. Continuous variables that were not normally distributed are presented as the median and interquartile range (IQR), whereas normally distributed values are presented as the mean±SD. The significance of differences was analyzed using the 2-sample Mann-Whitney U test and Chi-squared test, as appropriate. Two-tailed $P<0.05$ was considered significant. Survival curves were plotted using the Kaplan-Meier method for the primary composite

Table 2. Baseline Patient Characteristics

	All (n=268)	Over-80 (n=100)	Under-79 (n=168)	P value
Coronary risk factors				
Hypertension	186 (69)	78 (78)	108 (64)	0.02
Dyslipidemia	137 (51)	48 (48)	89 (53)	0.53
Diabetes	99 (37)	33 (33)	66 (39)	0.36
Smoker (current or past)	147 (55)	36 (36)	111 (66)	<0.01
Family history of CAD	29 (11)	6 (6)	23 (14)	0.07
Past medical history				
Prior MI	25 (9)	11 (11)	14 (8)	0.52
Prior PCI	31 (12)	12 (12)	19 (11)	0.85
Prior CABG	8 (3)	3 (3)	5 (3)	–
Baseline medication				
Antiplatelet therapy	75 (28)	40 (40)	35 (21)	<0.01
Anticoagulation therapy	23 (9)	11 (11)	12 (7)	0.27
ACEI/ARB	100 (37)	41 (41)	59 (35)	0.36
MRA	7 (3)	3 (3)	4 (2)	0.71
β-blocker	37 (14)	16 (16)	21 (13)	0.47
Statins	74 (28)	37 (37)	37 (22)	0.01
Oral antidiabetic agent	73 (27)	28 (28)	45 (27)	0.89
Valvular disease	25 (10)	22 (22)	3 (2)	<0.01
AS	15 (6)	12 (12)	3 (2)	<0.01
MR	8 (3)	7 (7)	1 (1)	<0.01

Unless indicated otherwise, data are presented as n (%). ACEI, angiotensin-converting enzyme inhibition; ARB, angiotensin receptor blocker; AS, aortic stenosis; CABG, coronary artery bypass grafting; CAD, coronary artery disease; MI, myocardial infarction; MR, mitral regurgitation; MRA, mineralocorticoid receptor antagonist; Over-80, patients aged ≥80 years; PCI, percutaneous coronary intervention; Under-79, patients aged ≤79 years.

Table 3. Management and Outcomes

	All (n=268)	Over-80 (n=100)	Under-79 (n=168)	P value
CAG findings and treatment				
CAG	258 (96)	92 (92)	166 (99)	<0.01
No. coronary lesions	1.97±1.00	2.09±1.03	1.90±0.97	0.19
Final TIMI flow grade	2.91±0.46	2.88±0.56	2.92±0.40	0.55
PCI	235 (88)	86 (86)	149 (89)	0.52
CABG	27 (10)	7 (7)	20 (12)	0.20
IABP	51 (19)	21 (21)	30 (18)	0.50
Impella	18 (7)	4 (4)	14 (8)	0.18
ECMO	19 (7)	4 (4)	15 (9)	0.13
Duration of DAT (days)	136±139	111±133	151±144	0.02
Bleeding event	78 (29)	34 (34)	44 (26)	0.2
Length of hospital stay (days)	14 [9–20]	18 [11–27]	12 [9–16]	<0.01
In-hospital death	28 (10)	17 (17)	11 (7)	<0.01
MACE	56 (21)	28 (28)	28 (17)	0.03
All-cause death	35 (13)	22 (22)	13 (8)	<0.01

Unless indicated otherwise, data are presented as median [interquartile range], mean }SD, or n (%). CAG, coronary angiography; DAT, dual antithrombotic therapy; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pumping; MACE, major adverse cardiovascular events; Over-80, patients aged ≥80 years; PCI, percutaneous coronary intervention; TIMI, Thrombolysis in Myocardial Infarction; Under-79, patients aged ≤79 years.

endpoint. Adjusted survival analysis was performed by fitting Cox regression analysis to identity independent predictors of 1-year mortality and MACE. All analyses were performed using JMP® version 14.2 (SAS Institute, Cary, NC, USA).

Results

Clinical Characteristics of AMI Patients

Of the 268 AMI patients who were admitted to Chikamori Hospital, there were 100 (37%) patients in the Over-80

Table 4. Logistic Regression Analysis

	OR	95% CI	P value
MACE			
Male	1.35	0.48–3.82	0.57
CPA on arrival	1.49	0.092–24.16	0.78
Killip class III–IV	3.51	1.21–10.19	0.02
PCI	0.28	0.54–4.50	0.07
Multivessel disease	0.52	0.17–1.59	0.26
All-cause death			
Male	1.93	0.52–7.14	0.32
CPA on arrival	1.09	0.041–28.56	0.96
Killip class III–IV	9.49	2.50–36.02	<0.01
PCI	0.13	0.025–0.69	0.02
Multivessel disease	0.35	0.081–1.48	0.15

CI, confidence interval; CPA, cardiopulmonary arrest; MACE, major adverse cardiovascular events; OR, odds ratio; PCI, percutaneous coronary intervention.

group and 168 (63%) patients in the Under-79 group (**Table 1**). The proportion of male patients was 55% (n=55) in the Over-80 group and 83% (n=139) in the Under-79 group (P<0.01). There was no difference in STEMI rates between the two groups; 61% (n=61) in the Over-80 group and 63% (n=106) in the Under-79 group (P=0.73). Severe HF, which was defined as Killip class III–IV, was more prevalent in the Over-80 group (35% [n=35]) than in the Under-79 group (21% [n=36]) with a significant difference (P<0.01). There was no difference in patients with cardiopulmonary arrest on arrival at the hospital between the two groups (P=0.61). There were no differences between the two groups in onset-to-door time; the time from onset of myocardial infarction to arrival at the hospital (P=0.81), and door-to-balloon time; the time from arrival at the hospital to coronary revascularization (P=0.20).

With respect to laboratory findings, there was no difference in creatine phosphokinase between the two groups. However, creatinine kinase-MB (CK-MB), high-sensitivity cardiac troponin T (hs-cTnT), B-type natriuretic peptide (BNP), aspartate aminotransferase and lactase dehydrogenase were all significantly higher in the Over-80 group.

Baseline Patient Characteristics

Coronary Risk Factors and Past Medical History Hypertension was significantly more prevalent in the Over-80 group (78% [n=78]) than in the Under-79 group (64% [n=108]; P=0.02; **Table 2**). Smoking history (current or past) was significantly more frequent in the Under-79 group (P<0.01). There were no differences between the two groups in history of myocardial infarction and previous history of PCI or coronary artery bypass grafting (CABG).

Baseline Medication Antiplatelet drugs and statins were taken more frequently in patients in the Over-80 group with a significant difference (P<0.01 and P=0.01, respectively).

Valvular Heart Diseases The valvular heart diseases, which were defined as moderate or severe severity, were mostly aortic stenosis (6% [n=15]) and mitral regurgitation (3% [n=8]), and they were significantly more prevalent in the Over-80 group (22% [n=22]) than in the Under-79 group (2% [n=3]; P<0.01).

Management and Outcomes

CAG Findings and Treatment Although the percentage of CAG performed was significantly lower in the Over-80 group (92% [n=92]) than in the Under-79 group (99% [n=166]; P<0.01), it is noticeable that CAG was performed

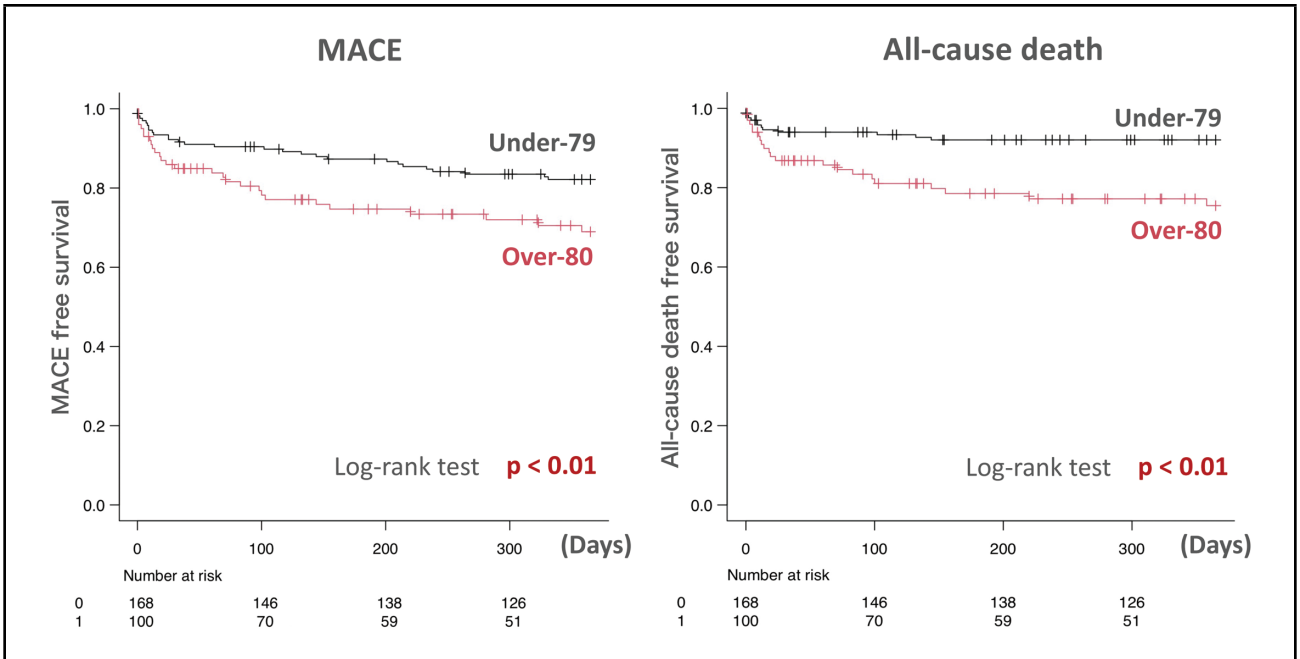

Figure 1. Cumulative incidence of major adverse cardiac events (MACE) and cumulative survival within 1 year in patients aged ≥80 years (Over-80) and those aged ≤79 years (Under-79).

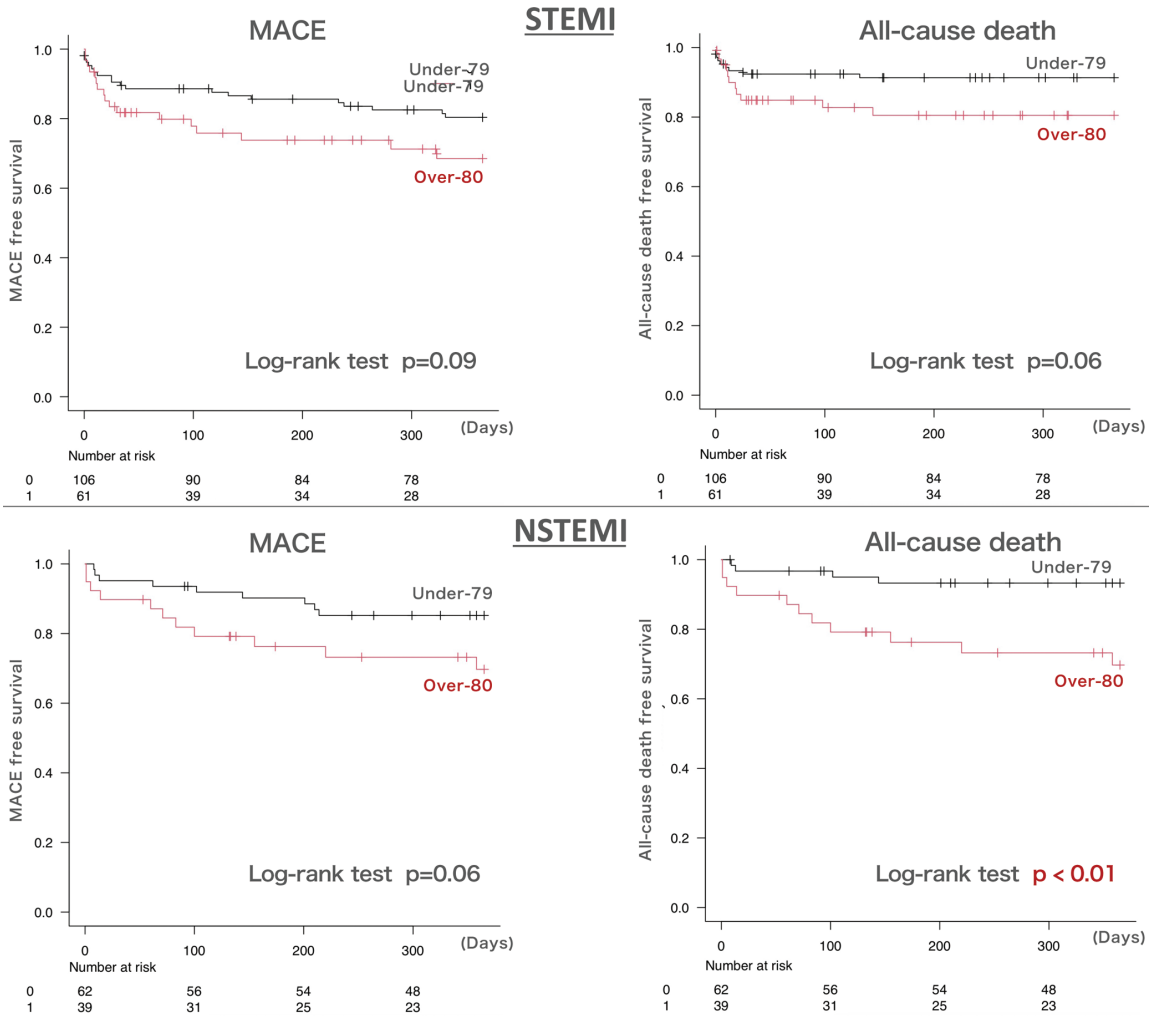

Figure 2. Outcomes of patients with ST-elevation myocardial infarction (STEMI) and non-ST-elevation myocardial infarction (NSTEMI). Over-80, patients aged ≥80 years; Under-79, patients aged ≤79 years.

in more than 90% of patients in the Over-80 group (**Tables 3**,**4**). There was no difference in the number of coronary lesions between the two groups (P=0.19), but there was a significant difference in TIMI flow grade among the two groups (P<0.01). Primary PCI was frequently and similarly performed in both the Over-80 group (86%) and the Under-79 group (89%; P=0.52), as was CABG (P=0.20). There was no difference between the two groups in the use of MCS, including intra-aortic balloon pumping (IABP), Impella and veno-arterial extracorporeal membrane oxygenation (VA-ECMO).

Outcomes The duration of dual antithrombotic therapy (DAT) after PCI was slightly shorter in the Over-80 group (111±133 days) than in the Under-79 group (151±144 days). The incidence of a bleeding event was not different between the two groups. There was no patients who died from a bleeding event. The length of hospitalization was significantly longer in the Over-80 group (18 days [IQR 11–27]) than in the Under-79 group (12 days [IQR 9–16]; P<0.01). The prevalence of in-hospital deaths was significantly higher in the Over-80 group (17%) compared with the Under-79 group (7%; P<0.01). MACE and all-cause death within 1 year were also more prevalent in the Over-80 group than in the Under-79 group (**Figure 1**). Logistic regression analysis performed for MACE and all-cause death within 1 year showed that Killip class III–IV was associated with MACE (odds ratio [OR] 3.51; P=0.02) and all-cause death (OR 9.49; P<0.01) in the Over-80 group. In contrast, and more importantly, PCI was inversely associated with all-cause death in the over-80 group (OR 0.13; P=0.02).

We also analysed the difference in outcomes of the patients with STEMI and those with NSTEMI. In the patients with STEMI, there was no difference in event-free survival between the Over-80 and the Under-79 groups, whereas in those with NSTEMI, all-cause death was more common in the Over-80 group (**Figure 2**).

With respect to frailty in the Over-80 group, 30 patients were assumed to be frail. These frail octogenarians and nonagenarians showed significantly worse clinical outcomes compared with the non-frail older patients and younger patients (**Figure 3**).

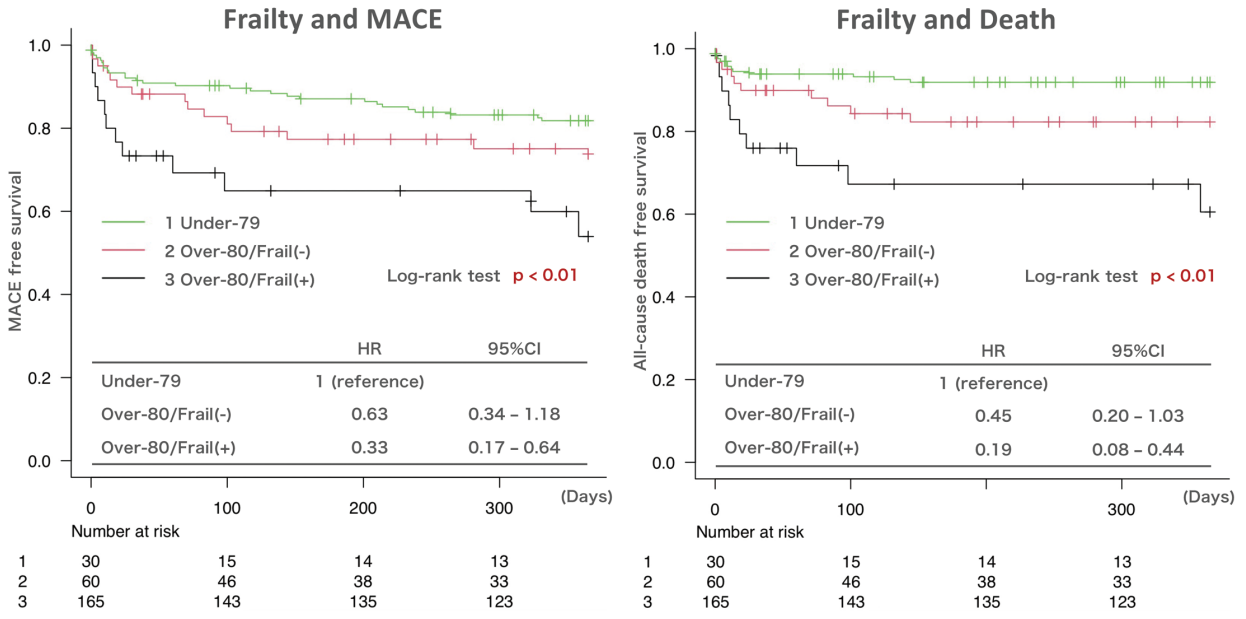

Figure 3. Significance of frailty in the incidence of major adverse cardiac events (MACE) and all-cause death. CI, confidence interval; HR, hazard ratio; Over-80, patients aged ≥80 years; Under-79, patients aged ≤79 years.

Discussion

The main findings of the present study are as follows: (1) the rate of primary PCI did not decline with age (i.e., primary PCI was performed similarly and frequently in both octogenarians and nonagenarians [86%] and younger patients [89%]); (2) octogenarians and nonagenarians showed more severe clinical presentation and worse short-term prognosis compared with younger patients; moreover, frail octogenarians and nonagenarians showed significantly worse outcomes compared with non-frail older patients; and (3) primary PCI in the acute phase was associated with a short-term reduced all-cause mortality even in the very old patients.

Older patients aged ≥80 years represent a growing proportion of the population presenting with AMI, but these patients are much less likely to receive invasive management. Data from the National Impatient Sample database in the USA showed that emergency CAG was performed in only 38% of patients with NSTEMI aged ≥81 years compared with 78% of patients aged ≤60 years.[13] The SENIOR-NSTEMI (Invasive Versus Non-invasive Management of Older Patients With Non-ST Elevation Myocardial Infarction) cohort study also showed that 49% of patients aged ≥80 years underwent invasive management.[7] Regarding STEMI, the Myocardial Ischemia National Audit Project (MINAP) reported that 32.2% of patients aged ≥85 years received primary PCI compared with 52.1% of those aged ≤55 years.[12] In contrast, the present study showed that 86% of octogenarians and nonagenarians received primary PCI during the acute phase, which was similar to the rate of primary PCI in the younger patients (89%). The results of the present study are remarkable and in line with temporal trends over the past decade, which have shown a growing use of invasive management in older adult patients in the acute phase, and also shown a positive association of this invasive approach with improved outcomes in older adult patients.[1,14,16,17] In contrast, it is important to be aware of the fact that older adult patients with AMI are at increased risk of complications such as bleeding,[18] although in the present study there was no difference in the incidence of a bleeding event between the very old patients and their younger counterparts. Also, they are often complicated by the complexity of geriatric syndrome including frailty, multimorbidity, impaired cognitive and physical function, and polypharmacy.[23] Thus, it is necessary to carefully consider the risk and benefit of an invasive approach in these very old adult patients with AMI.

Mortality in AMI increases with age.[24] Mortality rates in older patients with STEMI have ranged from 13% to 30% at 30 days, and as high as 52% at 3 years.[25–27] Regarding NSTEMI, 30-day mortality rates of patients aged ≥80 years have ranged between 12% and 16%, and 1-year mortality rates exceeding 25% have been reported.[28,29] Complications of AMI, such as HF, stroke, and cardiogenic shock, also increase in frequency with age.[25,30] In the present study, octogenarians and nonagenarians showed a more severe clinical presentation and a worse short-term prognosis compared with their younger counterparts. Killip class III–IV was more frequently found in octogenarians and nonagenarians than in younger patients. The level of biomarkers, such as BNP, hs-cTnT, and CK-MB, was found to be higher in octogenarians and nonagenarians than in younger patients. These clinical features resulted in a longer hospital stay and higher in-hospital death, as well as MACE and all-cause death within 1 year. These results are consistent with many previous reports, which showed that older patients with AMI have a more severe clinical presentation and are at higher risk of short-term and

long-term adverse outcomes compared with younger patients.[31,32] Moreover, in the present study, the significance of frailty in octogenarian and nonagenarians was evaluated in relation to their prognosis after an early invasive strategy. The frail octogenarians and nonagenarians were found to have worse clinical outcomes compared with the non-frail older patients. Thus, it is important to recognize that frailty is one of the significant prognostic markers in very old patients.

Current STEMI guidelines recommended early invasive management for reperfusion in older adult patients without contraindications.[25,33] An early invasive strategy for patients aged ≥75 years presenting with NSTEMI is still somewhat controversial.[28,34,35] In the context of STEMI, a pooled analysis of the TRIANA (Thrombectomy in Andalucia Using Aspiration), SENIOR-PAMI (Primary Angioplasty Versus Thrombolytic Therapy for Acute Myocardial Infarction in the Elderly), and Zwolle (The Zwolle Transmural Integrated Care for Cardiovascular Risk Management Study) trials showed a significant reduction of composite outcome of death, reinfarction, or disabling stroke with primary PCI compared with fibrinolysis.[5] In a pooled analysis of four French registries, including 3389 patients aged ≥75 years, early mortality decreased significantly from 25.0% to 8.4%.[36] This improvement was explained by the increasing use of early PCI. Based on this evidence, the 2017 European Society of Cardiology (ESC) STEMI guidelines, and also the recently introduced 2023 ESC guidelines for the management of acute coronary syndrome, state that there is no upper age limit with respect to reperfusion with primary PCI.[37,38] With respect to NSTEMI, evidence of benefit from a routine invasive strategy in older adult patients is not completely resolved. Among randomized clinical trials investigating an invasive strategy in older patients with NSTEMI, several trials have found no benefit of invasive treatment compared with conservative management.[39,40] In contrast, there are some trials that showed invasive treatment reduced reinfarction and urgent revascularization.[41,42] The Italian Elderly ACS trial, which randomly assigned patients aged ≥75 years with NSTEMI to early invasive vs. conservative management, showed a statistically not significant reduction in the rate of death, reinfarction, disabling stroke, or rehospitalization.[38] The After Eighty Study, which randomly assigned patients aged ≥80 years with NSTEMI or unstable angina to invasive vs. conservative management, demonstrated that the invasive strategy was superior to the conservative strategy in reducing composite events, including myocardial infarction, urgent revascularization, stroke, and death, from both a short-term and long-term perspective.[41,43] Using both observational and randomized data, systematic reviews and meta-analyses have shown a likely reduction in myocardial infarction and recurrent revascularization associated with an early invasive strategy.[44–46] In the present study, in the patients with STEMI, although there was no difference in event-free survival between the older patients and the younger patients, in those with NSTEMI all-cause death was more common in octogenarians and nonagenarians than in the younger counterparts. Logistic regression analysis revealed that primary PCI was inversely associated with 1-year all-cause mortality in octogenarians and nonagenarians. Therefore, the short-term survival benefit of invasive compared with non-invasive management appeared to extend to the very old adult patients with AMI.

Study Limitations

Several limitations merit being acknowledged. First, because this is a retrospective observational study, we cannot exclude a certain selection bias and the potential effect of unmeasured confounding. Second, the number of study patients was relatively small compared with many multicenter registries, because this is a study from a single institution. Further studies are needed to confirm our observations. Third, the significance of additional PCI of the nonculprit lesions compared with culprit lesion-only PCI was not discussed, partly because of the small number of patients in the study. Fourth, although very old patients with AMI are often complicated by the complexity of geriatric syndrome, including frailty, multimorbidity, impaired cognitive function and polypharmacy, only an evaluation of frailty was performed in the present study.

Conclusions

The rate of primary PCI did not decline with age. Primary PCI was performed frequently and similarly in both octogenarians and nonagenarians (86%) and younger counterparts (89%), which is not only remarkable but also in line with recent temporal trends of the growing use of acute invasive management in very old patients. Although octogenarians and nonagenarians showed more severe clinical presentation and worse short-term outcome compared with younger patients, particularly in those with frailty, the prognosis might be improved by an early invasive strategy, even in very old adult patients.

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Disclosures

All authors have no conflicts of interest to disclose.

IRB Information

The present study was approved by the Ethics Committee of Chikamori Hospital (Reference no. 525).

References

1. Schoenenberger AW, Radovanovic D, Windecker S, Iglesias JF, Pedrazzini G, Stuck AE, et al; AMIS Plus Investigators. Temporal trends in the treatment and outcomes of elderly patients with acute coronary syndrome. *Eur Heart J* 2016; **37:** 1304–1311.
2. DeLuca L, Olivari Z, Bolognese L, Lucci D, Gonzini L, Di Chiara A, et al. A decade of changes in clinical characteristics and management of elderly patients with non-ST elevation myocardial infarction admitted in Italian cardiac care units. *Open Heart* 2014; **1:** e000148.
3. De Luca L, Marini M, Gonzini L, Boccanelli A, Casella G, Chiarella F, et al. Contemporary trends and age-specific sex differences in management and outcome for patients with ST-segment elevation myocardial infarction. *J Am Heart Assoc* 2016; **5:** e004202.
4. Damluji AA, Forman DE, Wang TY, Chikwe J, Kunadian V, Rich MW, et al; American Heart Association Cardiovascular Disease in Older Populations Committee of the Council on Clinical Cardiology; Council on Lifestyle and Cardiometabolic Health; and Council on Cardiovascular Radiology and Intervention. Management of acute coronary syndrome in the older adult

population: A scientific statement from the American Heart Association. *Circulation* 2022; **146:** e1–e31.
5. Bueno H, Betriu A, Heras M, Alonso JJ, Cequier A, Garcia EJ, et al; TRIANA Investigators. Primary angioplasty vs. fibrinolysis in very old patients with acute myocardial infarction: TRIANA (TRatamiento del Infarto Agudo de miocardio eN Ancianos) randomized trial and pooled analysis with previous studies. *Eur Heart J* 2011; **32:** 51–60.
6. de Boer SP, Westerhout CM, Simes RJ, Granger CB, Zijlstra F, Boersma E; Primary Coronary Angioplasty Versus Thrombolysis-2 (PCAT-2) Trialists Collaborators Group. Death and morbidity reduction by primary percutaneous intervention is independent of the patient's age. *JACC Cardiovasc Interv* 2010; **3:** 324–331.
7. Kaura A, Sterna JAC, Trickey A, Abbott S, Mulla A, Glampson B, et al. Invasive versus non-invasive management of older patients with non-ST elevation myocardial infarction (SENIOR-NSTEMI): A cohort study based on routine clinical data. *Lancet* 2020; **396:** 623–634.
8. Gurwitz JH, Col NF, Avorn J. The exclusion of the elderly and women from clinical trials in acute myocardial infarction. *JAMA* 1992; **268:** 1417–1422.
9. Lee PY, Alexander KP, Hammill BG, Pasquali SK, Peterson ED. Representation of elderly persons and women in published randomized trials of acute coronary syndrome. *JAMA* 2001; **286:** 708–713.
10. Krumholz HM, Gross CP, Peterson ED, Barron HV, Radford MJ, Parsons LS, et al. Is there evidence of implicit exclusion criteria for elderly subjects in randomized trials? Evidence from the GUSTO-1 study. *Am Heart J* 2003; **146:** 839–847.
11. Alexander KP, Newby LK, Armstrong PW, Cannon CP, Gibler WB, Rich MW, et al; American Heart Association Council on Clinical Cardiology; Society of Geriatric Cardiology. Acute coronary care in the elderly, Part II: ST-segment-elevation myocardial infarction: A scientific statement for healthcare professionals from American Heart Association Council on Clinical Cardiology; in collaboration with the Society of Geriatric Cardiology. *Circulation* 2007; **115:** 2570–2589.
12. Gale CP, Cattle BA, Woolston A, Baxter PD, West TH, Simms AD, et al. Resolving inequalities in care? Reduced mortality in the elderly after acute coronary syndromes. The Myocardial Ischemia National Audit Project 2003–2010. *Eur Heart J* 2012; **33:** 630–639.
13. Rashid M, Fischman DL, Gulati M, Tamman K, Potts J, Kwok CS, et al. Temporal trends and inequalities in coronary angiography utilization in the management of non-ST-elevation acute coronary syndromes in the U.S. *Sci Rep* 2019; **9:** 240.
14. Madhavan MV, Gersh BJ, Alexander KP, Granger CB, Stone GW. Coronary artery disease in patients ≥80 years of age. *J Am Coll Cardiol* 2018; **71:** 2015–2040.
15. Skolnick AH, Alexander KP, Chen AY, Roe MT, Pollack CV Jr, Ohman EM, et al. Characteristics, management, and outcomes of 5557 patients age > or =90 years with acute coronary syndrome: Results from the CRUSADE Initiative. *J Am Coll Cardiol* 2007; **49:** 1790–1797.
16. Bucholz EM, Butala NM, Normand SL, Wang Y, Krumholz HM. Association of guideline-based admission treatments and life expectancy after myocardial infarction in elderly Medicare beneficiaries. *J Am Coll Cardiol* 2016; **67:** 2378–2391.
17. Morici N, De Servi S, De Luca L, Crimi G, Montalto C, De Rosa R, et al. Management of acute coronary syndromes in older adults. *Eur Heart J* 2022; **43:** 1542–1553.
18. Wallentin L, Becker RC, Budaj A, Cannon CP, Emanuelsson H, Held C, et al; PLATO Investigators. Ticagrelor versus clopidogrel in patients with acute coronary syndromes. *N Engl J Med* 2009; **361:** 1045–1057.
19. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. *Lancet* 2013; **381:** 752–762.
20. Fried LP, Tangen CM, Walston J, Newman, AB, Hirsch C, Gottdiener J, et al; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: Evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; **56:** M146–M156.
21. Clinical Frailty Scale-Geriatric Medicine Research-Dalhousie University. Faculty of Medicine, Geriatric Medicine Research, Research/Projects, Clinical Frailty Scale. Dalhousie University, Halifax, Canada. http://geriatricreasearch.medicine.dal.ca./clinical_frailty_scale.html (accessed April 25, 2024).
22. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowel I, et al. A global clinical measure of fitness and frailty in elderly people. *CMAJ* 2005; **173:** 489–495.
23. Damluji AA, Forman DE, van Diepen S, Alexander KP, Page RL, Hummel SL, et al; American Heart Association Council on Clinical Cardiology and Council on Cardiovascular and Stroke Nursing. Older adults in cardiac intensive care unit: Factoring geriatric syndromes in the management, prognosis, and process of care: A scientific statement from the American Heart Association. *Circulation* 2020; **141:** e6–e32.
24. Mehta RH, Rathore SS, Radford MJ, Wang Y, Wang Y, Krumholz HM. Acute myocardial infarction in the elderly: Difference by age. *J Am Coll Cardiol* 2001; **38:** 736–741.
25. Alexander KP, Newby LK, Armstrong PW, Cannon CP, Gibler WB, Rich MW, et al. Acute coronary care in the elderly, Part II: ST-segment-elevation myocardial infarction: A scientific statement for healthcare professionals from the American Heart Association Council on Clinical Cardiology: In collaboration with the Society of Geriatric Cardiology. *Circulation* 2007; **115:** 2570–2589.
26. Caretta G, Passamonti E, Pedroni PN, Fadin BM, Galeazzi GL, Pirelli S. Outcomes and predictors of mortality among octogenarians and older with ST-segment elevation myocardial infarction treated with primary coronary angioplasty. *Clin Cardiol* 2014; **37:** 523–529.
27. Bromage DI, Jones DA, Rathod KS, Grout C, Iqbal MB, Lim P, et al. Outcome of 1051 octogenarian patients with ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention: Observational cohort from the London Heart Attack Group. *J Am Heart Assoc* 2016; **5:** e003027.
28. Alexander KP, Newby LK, Cannon CP, Armstrong PW, Gibler WB, Rich MV, et al. Acute coronary care in the elderly, Part I: Non-ST-segment-elevation acute coronary syndrome: A scientific statement for healthcare professionals from the American Heart Association Council on Clinical Cardiology: In collaboration with the Society of Geriatric Cardiology. *Circulation* 2007; **115:** 2549–2569.
29. Lopes RD, Gharacholou SM, Holmes DN, Thomas L, Wang TY, Roe MT, et al. Cumulative incidence of death and rehospitalization among the elderly in the first year after NSTEMI. *Am J Med* 2015; **128:** 582–590.
30. Rich MW. Epidemiology, clinical features, and prognosis of acute myocardial infarction in the elderly. *Am J Geriatr Cardiol* 2006; **15:** 7–11; quiz 12.
31. Avezum A, Makdisse M, Spencer F, Gore JM, Fox KAA, Montalescot G, et al; GRACE Investigators. Impact of age on management and outcome of acute coronary syndrome: Observations from the Global Registry of Acute Coronary Events (GRACE). *Am Heart J* 2005; **149:** 67–73.
32. Granger CB, Goldberg RJ, Dabbous O, Pieper KS, Eagle KA, Cannon CP, et al; Global Registry of Acute Coronary Events Investigators. Predictions of hospital mortality in the global registry of acute coronary events. *Arch Intern Med* 2003; **163:** 2345–2353.
33. O'Gara PT, Kushner FG, Ascheim DD, Casey DE Jr, Chung MK, de Lemos JA, et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 2013; **61:** e78–e140.
34. Amsterdam EA, Wenger NK, Brindis RG, Casey DE Jr, Ganiats TG, Holmes DR Jr, et al. 2014 AHA/ACC guidelines for the management of patients with non-ST-elevation acute coronary syndrome: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 2014; **64:** e139–e228.
35. Bach RG, Cannon CP, Weintraub WS, DiBattiste PM, Demopoulos LA, Anderson HV, et al. The effect of routine, early invasive management on outcome for elderly patients with non-ST-segment elevation acute coronary syndrome. *Ann Intern Med* 2004; **141:** 186–195.
36. Puymirat E, Aissaoui N, Cayla G, Lafont A, Riant E, Mennuni M, et al; FAST-MI Investigators. Changes in one-year mortality in elderly patients admitted with acute myocardial infarction in relation with early management. *Am J Med* 2017; **130:** 555–563.
37. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, et al; ESC Scientific Document Group. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. *Eur Heart J* 2018; **39:** 119–177.
38. Byrne RA, Rossello X, Coughlan JJ, Barbato E, Berry C, Chieffo A, et al; ESC Scientific Document Group. 2023 ESC guidelines for the management of acute coronary syndrome. *Eur Heart J* 2023; **44:** 3720–3826.

39. Savonitto S, Cavallini C, Petronio AS, Murena E, Antonicelli R, Sacco A, et al. Early aggressive versus initially conservative treatment in elderly patients with non-ST-segment elevation acute coronary syndrome: A randomized controlled trial. *JACC Cardiovasc Interv* 2012; **5:** 906–916.
40. de Belder A, Myat A, Blaxill J, Haworth P, O'Kane PD, Hatrick P, et al. Revascularisation or medical therapy in elderly patients with acute anginal syndromes: The RINKAL randomised trial. *EuroIntervention* 2021; **17:** 67–74.
41. Tegn N, Abdelnoor M, Aaberge L, Endresen K, Smith P, Aakhus S, et al; After Eighty Study Investigators. Invasive versus conservative strategy in patients aged 80 years or older with non-ST-elevation myocardial infarction or unstable angina pectoris (After Eighty study): An open-label randomised controlled trial. *Lancet* 2016; **387:** 1057–1065.
42. Mills GB, Ratcovich H, Adams-Hall J, Beska B, Kirkup E, Raharjo DE, et al. Is the contemporary care of the older persons with acute coronary syndrome evidence-based? *Eur Heart J Open* 2022; **2:** oeab044.
43. Berg ES, Tegn NK, Abdelnoor M, Roysland K, Ryalen PC, Aaberge L, et al; on behalf of the After Eighty Study Investigators. Long-term outcomes of invasive vs conservative strategies for older patients with non-ST-segment elevation acute coronary syndromes. *J Am Coll Cardiol* 2023; **82:** 2021–2030.
44. Gnanenthiran SR, Kritharides L, D'Souza M, Lowe HC, Brieger DB. Revascularisation compared with initial medical therapy for non-ST-elevation acute coronary syndromes in the elderly: A meta-analysis. *Heart* 2017; **103:** 1962–1969.
45. Ma W, Liang Y, Zhu J. Early invasive versus initially conservative strategy in elderly patients older than 75 years with non-ST-elevation acute coronary syndrome: A meta-analysis. *Heart Lung Circ* 2018; **27:** 611–620.
46. Mehta SR. Complete revascularization in older patients with myocardial infarction. *N Engl J Med* 2023; **389:** 951–952.