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Original article

Temporal trends in the prevalence and outcomes of geriatric patients with acute myocardial infarction in Japan–A report from the Miyagi AMI Registry Study–☆

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A B S T R A C T

Background: Along with the global aging, the number of geriatric patients with acute myocardial infarction (AMI) has been increasing. However, temporal trends in the prevalence and outcomes of geriatric patients with AMI, with a special reference to heart failure (HF) on admission, remain to be elucidated.
Methods: The Miyagi AMI Registry is a prospective, multicenter, and observational study. This registry was established in 1979 and has been continued for 40 years. We examined a total of 6,596 AMI patients aged ≥70 years (male/female 4,141/2,455) registered in this registry from 2005 to 2016 and divided them into 3 groups according to age [70–79 (n = 3,485), 80–89 (n = 2,601), and ≥90 years (n = 510)].
Results: Of those, 17.6% had HF (Killip class ≥ II) on admission, for which age, female sex, diabetes, and previous MI were identified as independent predictors. Importantly, the prevalence of HF on admission significantly increased in all ages during the study period (all p for trend <0.01). Despite the presence of HF on admission, primary percutaneous coronary intervention (PCI) was performed in about 70% of patients aged in their 80 s and about half of those aged ≥90 years. In each group, performance rate of primary PCI also progressively increased (all $p < 0.05$) irrespective of concomitant HF. However, in-hospital mortality remained unchanged. Multivariable analysis demonstrated that, even for patients with HF on admission, primary PCI was associated with improved in-hospital mortality in the younger 2 groups [adjusted odds ratios (ORs), 95% confidence intervals (CI) 0.58 (0.36–0.93) for 70s, 0.64 (0.43–0.95) for 80s, and 0.99 (0.44–2.21) for ≥90s], whereas PCI was ineffective to reduce long-term hospitalization ≥30 days in all groups [adjusted ORs (95%CI) 0.90 (0.52–1.54), 0.66 (0.38–1.14), and 0.38 (0.07–2.10)].
Conclusions: These results demonstrate that increasing prevalence of HF on admission and increasing performance of primary PCI counteract each other with resultant unchanged in-hospital outcomes in geriatric AMI patients in Japan.

Introduction

The general population is rapidly aging worldwide especially in developed countries, where Japan has been standing at the forefront [1]. We have previously demonstrated that this trend is more evident in patients with acute myocardial infarction (AMI), which is one of the leading causes of death in Japan [2,3]. The invasive recanalization strategy in the critical care for AMI, especially primary percutaneous coronary intervention (PCI), provided a dramatic reduction in hospital mortality during the last several decades and thus is highly recommended for AMI patients [4–7]. However, low adherence to such guideline-recommended therapies is more common in elderly AMI patients [8]. Indeed, a high comorbidity burden and reduced life expectancy in elderly AMI patients has been largely responsible for the low

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penetration of primary PCI and their poor outcomes. In particular, coexisting heart failure (HF) is a well-known exacerbating factor for AMI and elderly AMI patients are more likely to develop HF compared with younger AMI patients [8]. It also has been reported that invasive treatments including PCI and coronary artery bypass graft for elderly AMI patients enhance the risks of serious periprocedural complications [9,10]. Indeed, we recently demonstrated that both aging and coexisting HF on admission were significantly associated with non-performance of primary PCI in Japan [11]. However, the prevalence and characteristics of elderly AMI patients with HF on admission is unclear in Japan, the most advancing super-aged society in the world. Furthermore, it also remains to be elucidated whether critical care and its impact differ depending on the presence or absence of symptomatic HF. Thus, in the present study, we examined the temporal trends in the prevalence and outcomes of geriatric patients with AMI with a special reference to coexisting HF on admission.

Methods

The present study was approved by the Institutional Review Board of Tohoku University Graduate School of Medicine (2017-1-284), under the condition that personal data are protected at all times.

The Miyagi-AMI Registry Study and study population

The Miyagi AMI Registry Study is a prospective, multicenter, and observational study. This registry was established in 1979 and has been continued for 40 years [2,3,11–13]. Since all 45 hospitals with a cardiac care unit and/or cardiac catheterization facilities in the Miyagi prefecture, which is located in the northeastern Japan with a population of approximately 2.35 million, have been participating in the Registry (Appendix A), almost all AMI patients in the Miyagi prefecture have been prospectively registered. The diagnosis of AMI was based on the WHO-MONICA criteria [14], including typical severe chest pain accompanied by ischemic electrocardiogram changes and increased serum levels of cardiac enzymes (e.g. creatinine phosphokinase, aspartate aminotransferase, and lactate dehydrogenase). Treatment strategies including the selection of reperfusion therapies were left to the discretion of individual cardiologists in charge. The information collected in the Miyagi AMI Registry Study included age, sex, date and time of symptom onset, prehospital management (e.g. use of ambulance, time interval from the onset of symptoms to admission), infarction site, coronary risk factors (hypertension, diabetes mellitus, dyslipidemia, and smoking), reperfusion therapies (e.g. thrombolysis and/or PCI), and in-hospital outcomes [2,3,12]. We revised the registration form occasionally during the 40 years as required. Thus, although the number of incidents of AMI and the basic demographic data (age, sex, and time of onset) are available for all patients over the entire period of 40 years, the data regarding prehospital managements, infarction site, coronary risk factors, reperfusion therapies, or in-hospital outcomes were only available for patients registered during the last 10–20 years [2,3,12]. Additionally, information on the type of AMI [ST-segment elevation MI (STEMI) vs. non-STEMI (NSTEMI)] was unavailable for most of the patients. Thus, in the present study, both STEMI and NSTEMI patients were enrolled with no distinction. In the Miyagi AMI Registry Study, AMI patients with out-of-hospital cardiac arrest who were brought in dead were not included.

A total of 13,187 AMI patients were enrolled in the Miyagi AMI Registry between 2005 and 2016. In the present study, after excluding 192 patients without the data regarding age or complicated HF on admission or both, and 6,339 patients aged <70 years, we finally analyzed 6,596 elderly AMI patients older than 70 years and divided them into 3 age groups (70–79, 80–89, and ≥90 years) (Supplementary Fig. S1). Then, we further divided them into 2 sub-groups by the presence or absence of symptomatic heart failure (HF) on admission that developed as a complication of AMI. HF was defined as the presence of pulmonary rales or the equivalent of Killip class ≥ II.

Statistical analysis

We examined the temporal trends in the prevalence of HF on admission, performance rate of primary PCI, and in-hospital mortality for the four 3-year periods (2005–2007, 2008–2010, 2011–2013, and 2014–2016) with the Cochran–Armitage trend test. Then, we performed univariable and multivariable logistic regression analyses to examine the effect of primary PCI on in-hospital mortality by sub-groups divided by the presence or absence of coexisting HF on admission with Killip class ≥ II. Furthermore, for survivors (n = 5,619), we also analyzed the hospitalization period of longer than 30 days. In the multivariate logistic regression analysis, we calculated the odds ratios (OR) and 95% confidence intervals (95% CI) of primary PCI for in-hospital mortality (adjusted by covariates, including age, sex, coronary risk factors, past AMI history, ambulance use, and cardiopulmonary arrest on admission) and those with long-term hospitalization ≥30 days (adjusted by covariates, including age, sex, coronary risk factors, and past AMI history). Categorical variables were summarized as percentages and compared among the groups applying the Pearson χ^2 test. A p-value <0.05 was considered to be statistically significant for all tests. All statistical analyses were performed using the statistical software SPSS statistics 21 (IBM Corp, Armonk, NY, USA) and JMP Pro 14.1.0 (SAS Institute, Cary, NC, USA).

Results

Clinical characteristics of elderly AMI patients in Japan

Patient characteristics by age are summarized in Table 1. The percentage of females increased with age and older patients were less likely to have coronary risk factors, such as dyslipidemia, diabetes, or smoking. Among all patients, 17.6% had symptomatic HF (Killip class ≥ II) on hospital arrival and primary PCI performance rate was 77.4%. With advancing age, the incidence of coexisting HF on admission increased and a robust decrease in primary PCI performance rate was noted. In-hospital mortality increased about 2-fold as age of onset became older by 10 years. The multivariable logistic regression model with all patients showed that age and coexisting HF on admission were associated with increased risk of in-hospital mortality [adjusted OR (95%CI), 1.06 (1.05–1.08), 2.91 (2.47–3.44), respectively], whereas primary PCI correlated with the improvement of in-hospital mortality [adjusted OR (95%CI) 0.37 (0.31–0.43)] (Table 2).

Temporal trends in the incidence of HF on admission and performance rate of primary PCI in geriatric AMI patients

In-hospital mortality was about 3-times higher in elderly AMI patients with HF on admission as compared with those without it (32.9% vs. 11.0%, $p < 0.001$) (Table 3). Factors associated with HF on admission identified by logistic regression analysis were age, female sex, diabetes mellitus, and previous MI (Table 4). Importantly, the prevalence of HF with Killip class ≥ II on admission had significantly increased over the four 3-year periods (Fig. 1A). Especially, at the last 3-year period (2014–2016), the prevalence of HF was higher compared with other periods in all age groups (70–79 years, 20.0%; 80–89 years, 27.4%; and ≥90 years, 39.7%).

Table 1
Demographic patient characteristics.

Age, median (IQR)	Overall (n = 6,596) 79 (10)		70–79 years (n = 3,485) 75 (5)		80–89 years (n = 2,601) 83 (5)		≧90 years (n = 510) 92 (3)		p-Value
Female (%)	2,455	(37.2)	1,027	(29.5)	1,129	(43.4)	299	(58.6)	<0.001
HT (%)	4,608	(69.9)	2,408	(69.1)	1,851	(71.2)	349	(68.4)	0.17
DM (%)	2,207	(33.5)	1,292	(37.1)	795	(30.6)	120	(23.5)	<0.001
DL (%)	2,040	(30.9)	1,236	(35.5)	692	(26.6)	112	(22.0)	<0.001
Smoking (%)	1,377	(20.9)	915	(26.3)	420	(16.1)	42	(8.2)	<0.001
Previous MI (%)	537	(8.9)	266	(8.3)	223	(9.5)	48	(10.1)	0.18
HF on admission (%)	1,158	(17.6)	485	(13.9)	537	(20.6)	136	(26.7)	<0.001
Ambulance use (%)	4,518	(68.5)	2,301	(66.0)	1,850	(71.1)	367	(72.0)	<0.001
Primary PCI (%)	5,103	(77.4)	2,857	(82.0)	1,971	(75.8)	275	(53.9)	<0.001
In-hospital mortality (%)	977	(14.8)	345	(9.9)	464	(17.8)	168	(32.9)	<0.001

DL, dyslipidemia; DM, diabetes mellitus; HF, heart failure; HT, hypertension; MI, myocardial infarction; PCI, percutaneous coronary intervention.

Table 2
Prognostic factors of in-hospital mortality (logistic regression analysis).

	Univariable analysis			Multivariable analysis		
	OR	95%CI	p-Value	OR	95%CI	p-Value
Age	1.08	1.07–1.10	<0.001	1.06	1.05–1.08	<0.001
Female sex	1.44	1.25–1.65	<0.001	1.21	1.03–1.42	0.019
HT	0.58	0.50–0.66	<0.001	0.64	0.54–0.75	<0.001
DM	1.02	0.89–1.18	0.76	1.21	1.03–1.43	0.023
DL	0.49	0.41–0.58	<0.001	0.66	0.55–0.79	<0.001
Smoking	0.60	0.50–0.72	<0.001			
Previous MI	1.48	1.18–1.86	0.001			
Ambulance use	1.24	1.07–1.45	0.005			
HF on admission	3.98	3.43–4.63	<0.001	2.91	2.47–3.44	<0.001
Primary PCI	0.25	0.22–0.29	<0.001	0.37	0.31–0.43	<0.001

DL, dyslipidemia; DM, diabetes mellitus; HF, heart failure; HT, hypertension; MI, myocardial infarction; PCI, percutaneous coronary intervention.

Table 3
Patient characteristics by the presence or absence of HF on admission.

	Without HF (n = 5,438)		With HF (n = 1,158)		p-Value
	n	(%)	n	(%)	
Age, median (IQR)	81	(10)	89	(10)	<0.001
Female sex	1,956	(36.0)	499	(43.1)	<0.001
HT	3,813	(70.1)	795	(68.7)	0.32
DM	1,749	(32.2)	458	(39.6)	<0.001
DL	1,734	(31.9)	306	(26.4)	<0.001
Smoking	1,148	(21.1)	229	(19.8)	0.31
Previous MI	383	(7.0)	154	(13.3)	<0.001
Ambulance use	3,623	(66.6)	895	(77.3)	<0.001
Primary PCI	4,399	(80.9)	704	(60.8)	<0.001
In-hospital mortality	596	(11.0)	381	(32.9)	<0.001
Long-term hospitalization[a]	564	(13.6)	274	(44.3)	<0.001

DL, dyslipidemia; DM, diabetes mellitus; HF, heart failure; HT, hypertension; MI, myocardial infarction; PCI, percutaneous coronary intervention.
[a] 5,619 patients survived to discharge were analyzed.

Table 4
Factors associated with heart failure on admission in elderly acute MI patients.

	Univariable analysis			Multivariable analysis		
	OR	95%CI	p-Value	OR	95%CI	p-Value
Age	1.05	1.04–1.06	<0.001	1.05	1.04–1.06	<0.001
Female sex	1.35	1.19–1.53	<0.001	1.23	1.07–1.42	0.003
HT	0.93	0.81–1.07	0.324			
DM	1.38	1.21–1.57	<0.001	1.49	1.30–1.72	<0.001
DL	0.77	0.67–0.89	<0.001	0.77	0.66–0.89	0.001
Smoking	0.92	0.79–1.08	0.310			
Previous MI	1.97	1.61–2.40	<0.001	1.99	1.62–2.44	<0.001

DL, dyslipidemia; DM, diabetes mellitus; HT, hypertension; MI, myocardial infarction.

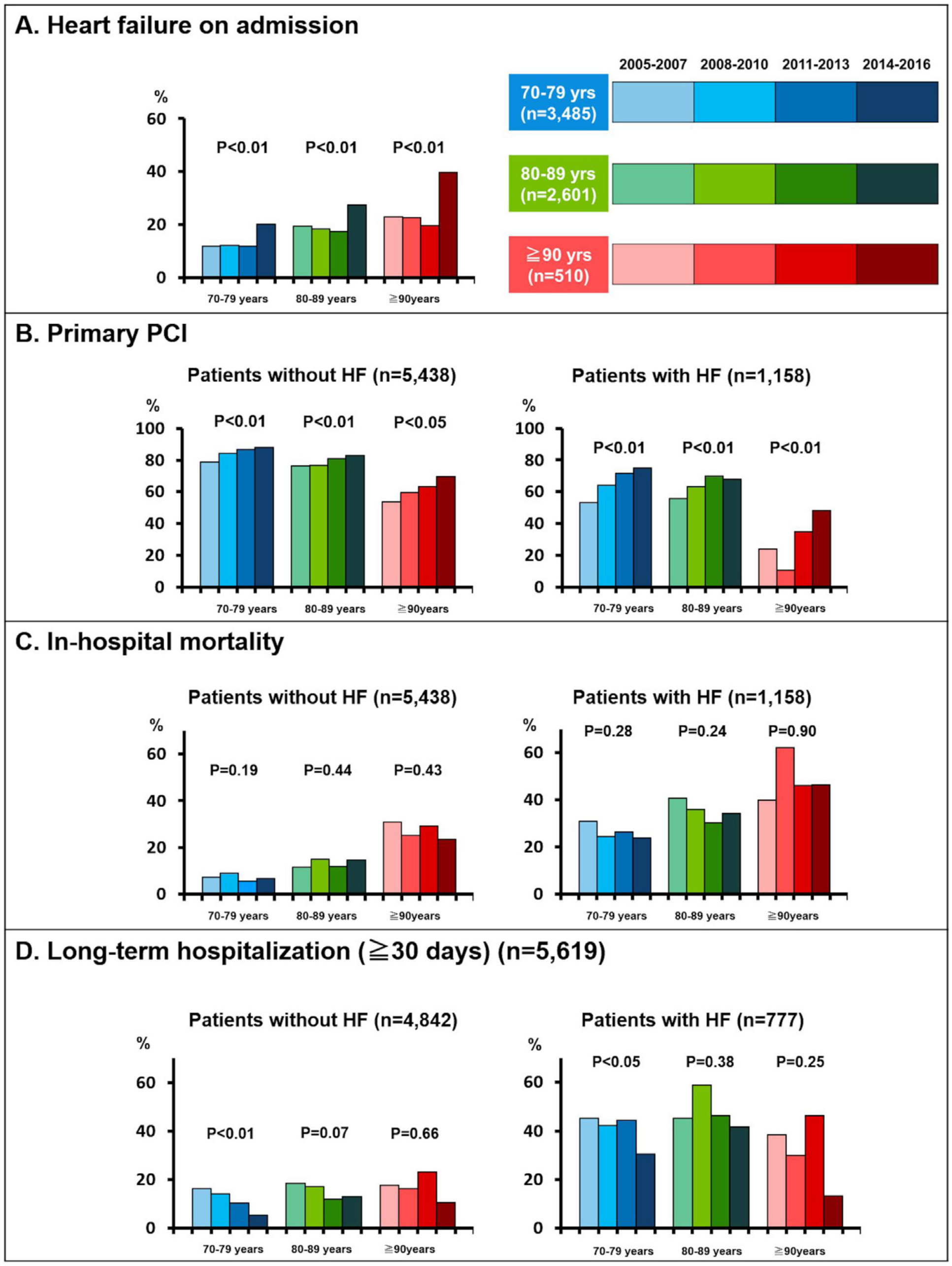

Fig. 1. Temporal trends in the prevalence of elderly AMI patients with heart failure on admission (A), performance rate of primary PCI by the presence or absence of HF on admission (B), in-hospital mortality by the presence or absence of HF on admission (C), prevalence of long-term hospitalization (≥30 days) among elderly AMI survivors (n = 5,619) by the presence or absence of HF on admission (D).
Patient number of each 3-year period group by age is summarized in Supplementary Table.
AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; HF, heart failure.

Simultaneously, the prevalence of coronary risk factors, including hypertension, diabetes mellitus, and smoking in the geriatric AMI patients, also tended to increase over time (Fig. 2A and B). The increasing tendency in the performance rate of primary PCI was noted even in elderly AMI patients regardless of HF on admission (Fig. 1B). In particular, in recent cases without HF on admission, the performance rate of primary PCI exceeded 80% in patients aged 80–89 years and 60% even in patients aged ≥90 years. Accordingly, in-hospital mortality remained unchanged regardless of age or the presence or absence of HF during the entire period (Fig. 1C). Among patients who survived to discharge (n = 5,619), the longer hospital stay ≥30 days significantly decreased only in patients aged in their 70 s, but not in more elderly patients (Fig. 1D).

Difference in the impact of primary PCI on geriatric AMI patients with or without HF on admission

Fig. 3 shows the results of multivariable analysis by groups classified by the presence or absence of coexisting HF on admission. Unless the elderly AMI patients had HF on admission, primary PCI was associated with both improvement of in-hospital mortality and reduced the incidence of long-term hospital stay in all age groups. Furthermore, even in the patients with HF on admission in their 70 s and 80 s, but not in those over 90 s, primary PCI was also associated with improved in-hospital mortality [adjusted ORs (95%CI) 0.58 (0.36–0.93) for 70 s, 0.64 (0.43–0.95) for 80 s, and 0.99 (0.44–2.21) for ≥90 s]. However, among the patients

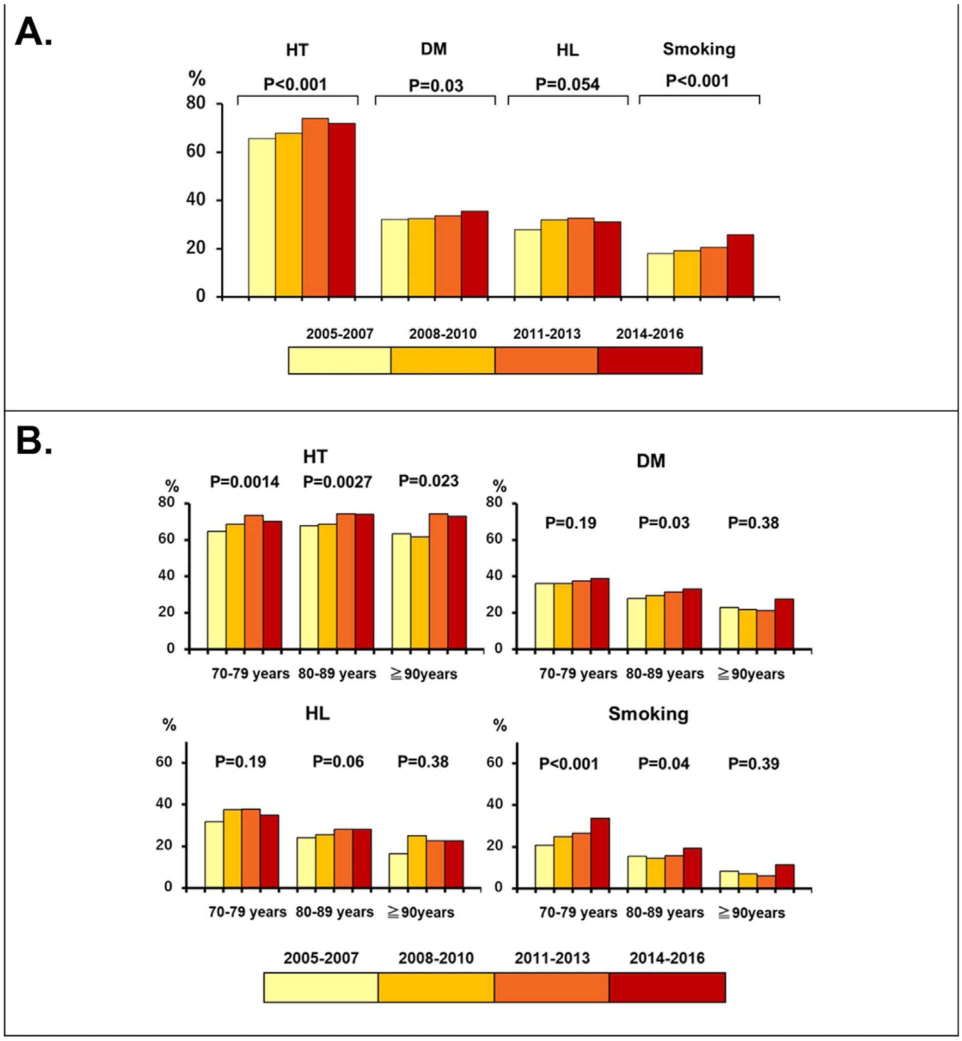

Fig. 2. Temporal trends in the prevalence of coronary risk factors for all patients (A). Temporal trends in the prevalence of coronary risk factors by age (B). DM, diabetes mellitus; HL, hyperlipidemia; HT; hypertension.

with HF on admission who survived to discharge, primary PCI was ineffective in reducing the risk of long-term hospitalization ≥30 days [adjusted ORs (95%CI) 0.90 (0.52–1.54) for 70 s, 0.66 (0.38–1.14) for 80 s, and 0.38 (0.07–2.10) for ≥90 s].

Discussion

In the present study, we examined the prevalence and long-term outcomes of geriatric AMI patients aged ≥70 years in Japan with a special reference to coexisting HF on admission. The major findings of the present study were as follows: (1) Among the elderly patients with AMI, coexisting HF on admission was common and its incidence increased with aging, along with a decrease in the performance rate of primary PCI. (2) Recently, among all age groups, temporal trends in the incidence of HF on admission and the performance rate of primary PCI have been increasing, whereas in-hospital mortality remained unchanged. (3) In cases with HF on admission in their 70 s and 80 s, primary PCI was associated with improved in-hospital mortality, but not with improved long hospital stay ≥30 days in all age groups. These results indicate that increasing prevalence of HF on admission and increasing performance of primary PCI counteract each other with resultant unchanged in-hospital outcomes in geriatric AMI patients in Japan.

AMI associated with heart failure on admission in contemporary elderly patients

It has been shown that older patients with AMI are more likely to have HF and less likely to undergo primary PCI regardless of MI types (STEMI or NSTEMI) [8,15]. Since geriatric patients often have other comorbidities in addition to HF, such as cognitive decline, anemia, and renal dysfunction [16–18], concerns about additional complications in such vulnerable elderly patients could make physicians hesitate to perform primary PCI. Indeed, as we previously demonstrated, aging and HF with Killip class ≥II on admission were associated with non-performance of primary PCI in Japan [11]. The present study confirmed that coexisting HF on admission and non-performance of primary PCI, both of which more often happen with advancing age, were closely associated with in-hospital death among contemporary Japanese AMI patients aged ≥70 years. Importantly, we demonstrated the increasing trends in the prevalence of symptomatic HF on admission in all 3 age groups (Fig. 1A) between 2005 and 2016, especially during the last 3 years (2014–2016). These results were in contrast to the previous report from the SWEDEHEART Registry Study, a nation-wide AMI registry in Sweden, that the incidence of HF (Killip class ≥II) during hospitalization decreased from 46% to 28% among 199,851 AMI patients registered between 1996 and 2008 [19]. We consider that this discrepancy between the 2 registry

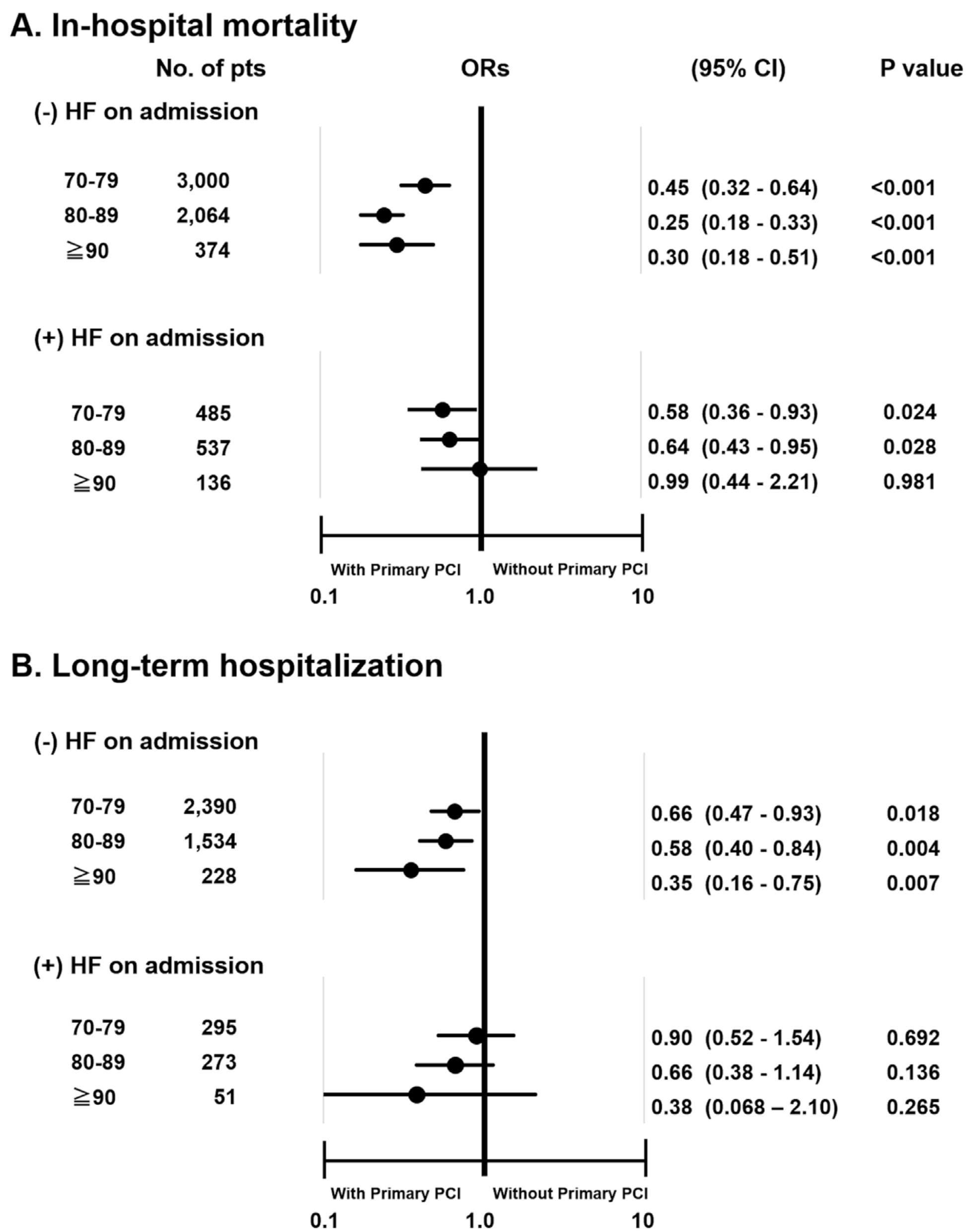

Fig. 3. (A) Odds ratios of primary PCI for in-hospital mortality adjusted by covariates, including age, sex, coronary risk factors, past AMI history, ambulance use and cardiopulmonary arrest on admission by the presence or absence of HF on admission. (B) Odds ratios of primary PCI for long-term hospitalization adjusted by covariates, including age, sex, coronary risk factors, and past AMI history among elderly AMI survivors (n = 5,619) by the presence or absence of HF on admission.
AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; HF, heart failure; OR, odds ratio; CI, confidence interval.

studies could be explained as follows: First, the elderly patients ≥70 years in the present study were older than those in the Swedish study (mean age, 79.6 vs. 70.9 years-old). Since elderly patients are more likely to develop HF [8,15,20], this approximate 10-year age gap between the 2 studies may have been involved in the difference in the prevalence of HF on admission. Indeed, the population-based cohort study from Canada with elderly patients ≥65 years also demonstrated that the incidence of in-hospital HF after MI had increased [21]. Second, the timing of evaluation for the presence or absence of HF was different; in the present study, we examined symptomatic HF at hospital arrival, while in the Swedish study, HF was evaluated after admission. Thus, the present study reflects the temporal change in the severity of AMI on admission, while the Swedish study rather reflects the improvement of critical care after admission, including primary PCI and the latest evidence-based medical therapies. Intriguingly, as shown in Fig. 2A and B, the prevalence of coronary risk factors tended to increase in the present study. It is conceivable that recent geriatric AMI patients in Japan have more advanced coronary artery disease with reduced cardiac reserve than before, and thus are more prone to develop decompensated HF on admission.

Beneficial effect of primary PCI on in-hospital outcomes in geriatric AMI patients with and without HF on admission

Previous studies from western countries demonstrated the increasing PCI performance even for geriatric AMI patients [15,22]. Similarly, in the present study in Japan, the performance rate of primary PCI has been continuously increasing over time, although the incidence of HF on admission, a predictor for non-performance of primary PCI [11], has also been increasing in the same period. Especially during the last 3 years (2014–2016), primary PCI was performed in about 70% of patients aged in their 80 s and about half of those aged ≥90 years despite the presence of coexisting HF. This suggests the high penetration of the guideline-based therapies including primary PCI even among oldest patients with AMI in Japan [4–7]. Furthermore, the present study indicates that primary PCI could reduce in-hospital death in AMI patients, not only in all age groups without HF but also in the younger groups (70 s and 80 s) with HF on admission. This finding is consistent with the recent randomized controlled trial, After Eighty Study, which demonstrated that an invasive strategy such as primary PCI was superior to a conservative strategy in AMI patients aged 80 s and that the efficacy of PCI may be attenuated in AMI patients aged ≥90 years [23]. Furthermore, a recent report from J-PCI registry demonstrated that patients aged ≥90 years undergoing primary PCI had higher risk of bleeding complications compared with other younger ages [24]. Also, in our nonagenarians with AMI and HF on admission, increasing incidence of bleeding complications may have resulted in the poor performance of PCI. It would be therefore useful for the elderly AMI patients to be admitted and treated in the intensive care unit as presented in a recent report [25]. The length of hospital stay is another important issue in health care. A study from a large-scale, contemporary US national registry showed that geriatric AMI patients with a long hospital stay were older, had more comorbidities including HF, and were more likely to have multi-vessel coronary artery disease and cardiogenic shock [26]. In the present study, among the subjects who survived in the acute period, long-term hospitalization ≥30 days was noted more frequently in those complicated with HF on admission (Table 3). The present study showed that primary PCI was effective in reducing the incidence of long-term hospital stay in all age groups without HF on admission, but not in those with it. These findings are consistent with a recent report from Japan showing that the hospital stay including cardiac rehabilitation program was significantly longer in AMI patients with Killip 3 or 4 H F at initial presentation [27]. Elderly HF patients are more likely to have reduced appetite, poor gastrointestinal functions, reduced muscle volumes, and impaired physical activity, resulting in malnutrition and frailty [28,29]. Thus, elderly survivors of AMI with HF on admission need more comprehensive therapies other than primary PCI, such as intensive drug therapies, cardiac rehabilitation, and nutritional care. Additionally, we also should pay attention to the fact that they would continue to have a high-long-term mortality hazard [19,21]. The number of patients with HF has been rapidly increasing worldwide, which is called the 'HF pandemic' [30]. Indeed, the NHANES Study in the USA reported the increasing prevalence of HF during the period from 2007 to 2014, which was more remarkable as compared with before [31]. In Japan, we found that the prevalence of ischemic HF accounted for 25.3% in our CHART-1 Study between 2000 and 2004, and was markedly increased to 47.1% in the CHART-2 Study between 2006 and 2010 [32]. This provides the evidence that the increased prevalence of ischemic HF after AMI has been counteracted by the improved mortality due to better implementation of primary PCI. In other words, the present study implicates that the efficacy of contemporary therapeutic strategy with primary PCI is limited to further extend life expectancy in the current era as the number of geriatric AMI patients with HF on admission has been increasing.

Study limitations

Several limitations should be mentioned for the present study. First, although almost all AMI patients were transferred to participating hospitals in the Miyagi Prefecture, a small number of AMI patients might have been admitted to other hospitals not participating in the Miyagi AMI Registry Study. Second, since the Miyagi-AMI Registry Study did not include angiographic data before 2012, we were unable to examine the performance rate of diagnostic coronary angiography or the influence of angiographic findings on the implementation of primary PCI for all elderly patients with AMI. Furthermore, therapeutic strategies for elderly AMI patients were left to the discretion of each attending physician. Thus, we were unable to reveal the precise reason why primary PCI was not performed for some patients. Third, since information on the type of AMI was unavailable for most of the patients in the present study, we were unable to analyze the difference between STEMI and NSTEMI. Fourth, in the Miyagi-AMI Registry Study, no data were available for assessing patient's status other than cardiovascular function, such as renal and cognitive functions, degree of frailty, or functional state assessed by New York Heart Association classification. Thus, it was difficult for us to determine the reasons why primary PCI was not performed or hospital stay was prolonged in each elderly AMI patient with HF on admission. Fifth, in the Miyagi-AMI Registry Study, no data were available for long-term outcomes of AMI patients after discharge.

Conclusion

In the present study, we were able to demonstrate that increasing prevalence of HF on admission and increasing performance of primary PCI counteract each other with resultant unchanged in-hospital outcomes in geriatric AMI patients in Japan.

Funding

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Disclosures

The authors declare that there is no conflict of interest.

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Appendix A

List of 45 Participating Hospitals in the Miyagi AMI Registry Study

Tohoku University Hospital: Departments of Cardiovascular Medicine, Cardiovascular Surgery, Gastroenterology. Tohoku University: Department of Medical Engineering and Cardiology, Institute of Development, Aging and Cancer. Fukaya Hospital. Hikarigaoka Spellman Hospital. Ishinomaki Medical Association. Ishinomaki Municipal Hospital. Ishinomaki Red-Cross Hospital. Japan Community Health Care Organization Sendai Hospital and Sendai South Hospital. JR Sendai Hospital. Katta General Hospital. Kesen-numa City Hospital. Kurihara City Central Hospital. Labour Welfare Corporation Tohoku Rosai Hospital. Marumori National Health Insurance Hospital. Miyagi Eastern Cardiovascular Medicine. Miyagi Northern Cardiovascular Center Mori Hospital. Miyagi Prefectural Cancer Center. Miyagi Prefectural Cardiovascular and Respiratory Center. Nagamachi Hospital. Nishitaga National Hospital. NTT East Tohoku Hospital. Oizumi Memorial Hospital. Osaki Citizen Hospital. Saito Hospital. Saka General Hospital. Sendai Cardiovascular Center. Sendai City Hospital. Sendai Kosei

Hospital. Sendai Medical Center. Sendai Open Hospital Sendai City Medical Center. Sendai Red-Cross Hospital. Sendai Tokushukai Hospital. Senen General Hospital. Shichigashuku National Health Insurance Clinic. Shiogama City Hospital. South Miyagi Medical Center. Southern Tohoku General Hospital. Tohoku Kosai Hospital. Tohoku Pharmaceutical University Hospital. Tome Citizen Hospital. Toyoma Clinic in Tome City.

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jjcc.2019.10.006.

References

[1] International Population Reports. U.S. Government Printing Office, Washington DC. http://www.census.gov/library/publications/2016/demo/P95-16-1.html.
[2] Takii T, Yasuda S, Takahashi J, Ito K, Shiba N, Shirato K, et al. Trends in acute myocardial infarction incidence and mortality over 30 years in Japan. Circ J 2010;74:93–100.
[3] Cui Y, Hao K, Takahashi J, Miyata S, Shindo T, Nishimiya K, et al. Age-specific trends in the incidence and in-hospital mortality of acute myocardial infarction over 30 years in Japan—report from the Miyagi AMI Registry Study. Circ J 2017;81:520–8.
[4] JCS Joint Working Group. Guidelines for secondary prevention of myocardial infarction (JCS 2011). Circ J 2013;77:231–48.
[5] Ozaki Y, Katagiri Y, Onuma Y, Amano T, Muramatsu T, Kozuma K, et al. CVIT expert consensus document on primary percutaneous coronary intervention (PCI) for acute myocardial infarction (AMI) in 2018. Cardiovasc Interv Ther 2018;33:178–203.
[6] Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, et al. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J 2017;39:119–77.
[7] O'Gara PT, Kushner FG, Ascheim DD, Casey DE, Chung MK, de Lemos JA, et al. 2013 ACCF/AHA guideline for the management of ST-Elevation myocardial infarction. Circulation 2012;127:e362–425.
[8] Justin Zaman M, Stirling S, Shepstone L, Ryding A, Flather M, Bachmann M, et al. The association between older age and receipt of care and outcomes in patients with acute coronary syndromes: a cohort study of the Myocardial Ischaemia National Audit Project (MINAP). Eur Heart J 2014;35:1551–8.
[9] Batchelor WB, Anstrom KJ, Muhlbaier LH, Grosswald R, Weintraub WS, O'Neill WW, et al. Contemporary outcome trends in the elderly undergoing percutaneous coronary interventions: results in 7,472 octogenarians. J Am Coll Cardiol 2000;36:723–30.
[10] Alexander KP, Anstrom KJ, Muhlbaier LH, Grosswald RD, Smith PK, Jones RH, et al. Outcomes of cardiac surgery in patients age ≥80 years: results from the national cardiovascular network. J Am Coll Cardiol 2000;35:731–8.
[11] Hao K, Takahashi J, Ito K, Miyata S, Nihei T, Nishimiya K, et al. Clinical characteristics of patients with acute myocardial infarction who did not undergo primary percutaneous coronary intervention—Report from the MIYAGI-AMI Registry Study. Circ J 2015;79:2009–16.
[12] Hao K, Yasuda S, Takii T, Ito Y, Takahashi J, Ito K, et al. Urbanization, life style changes and the incidence/in-hospital mortality of acute myocardial infarction in Japan. Circ J 2012;76:1136–44.
[13] Hao K, Takahashi J, Ito K, Miyata S, Sakata Y, Nihei T, et al. Emergency care of acute myocardial infarction and the great east Japan earthquake disaster. Circ J 2014;78:634–43.
[14] Palomäki P, Miettinen H, Mustaniemi H, Lehto S, Pyörälä K, Mähönen M, et al. Diagnosis of acute myocardial infarction by MONICA and FINMONICA diagnostic criteria in comparison with hospital discharge diagnosis. J Clin Epidemiol 1994;47:659–66.
[15] Khera S, Kolte D, Palaniswamy C, Mujib M, Aronow WS, Singh T, et al. ST-elevation myocardial infarction in the elderly - Temporal trends in incidence, utilization of percutaneous coronary intervention and outcomes in the United States. Int J Cardiol 2013;168:3683–90.
[16] Breteler MMB, Claus JJ, Grobbee DE, Hofman A. Cardiovascular disease and distribution of cognitive function in elderly people: the Rotterdam study. BMJ 1994;308:1604–8.
[17] Mamas MA, Kwok CS, Kontopantelis E, Fryer AA, Buchan I, Bachmann MO, et al. Relationship between anemia and mortality outcomes in a national acute coronary syndrome cohort: insights from the UK Myocardial Ischemia National Audit Project Registry. J Am Heart Assoc 2016;5e003348.
[18] Mehta RH, Rathore SS, Radford MJ, Wang Y, Wang Y, Krumholz HM. Acute myocardial infarction in the elderly: differences by age. J Am Coll Cardiol 2001;38:736–41.
[19] Desta L, Jernberg T, Löfman I, Hofman-Bang C, Hagerman I, Spaak J, et al. Incidence, temporal trends, and prognostic impact of heart failure complicating acute myocardial infarction. The SWEDEHEART Registry (Swedish web-system for enhancement and development of evidence-based care in heart disease evaluated according to recommended therapies): a study of 199,851 patients admitted with index acute myocardial infarctions, 1996 to 2008. JACC Heart Fail 2015;3:234–42.
[20] Kojima S, Nishihira K, Takegami M, Nakao YM, Honda S, Takahashi J, et al. Nationwide real-world database of 20,462 patients enrolled in the Japanese Acute Myocardial Infarction Registry (JAMIR): impact of emergency coronary intervention in a super-aging population. IJC Heart Vasc 2018;20:1–6.
[21] Ezekowitz JA, Kaul P, Bakal JA, Armstrong PW, Welsh RC, McAlister FA. Declining in-hospital mortality and increasing heart failure incidence in elderly patients with first myocardial infarction. J Am Coll Cardiol 2009;53:13–20.
[22] Schoenenberger AW, Radovanovic D, Windecker S, Iglesias JF, Pedrazzini G, Stuck AE, et al. Temporal trends in the treatment and outcomes of elderly patients with acute coronary syndrome. Eur Heart J 2016;37:1304–11.
[23] Tegn N, Abdelnoor M, Aaberge L, Endresen K, Smith P, Aakhus S, et al. 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;387:1057–65.
[24] Numasawa Y, Inohara T, Ishii H, Yamaji K, Kohsaka S, Sawano M, et al. Comparison of outcomes after percutaneous coronary intervention in elderly patients, including 10,628 nonagenarians: insights from a Japanese Nationwide Registry (J-PCI Registry). J Am Heart Assoc 2019;8:1–13.
[25] Miki R, Takeuchi M, Imai T, Seki T, Tanaka S, Nakamura M, et al. Association of intensive care unit admission and mortality in patients with acute myocardial infarction. J Cardiol 2019;74:109–15.
[26] Swaminathan RV, Rao SV, McCoy LA, Kim LK, Minutello RM, Wong SC, et al. Hospital length of stay and clinical outcomes in older STEMI patients after primary PCI: a report from the National Cardiovascular Data Registry. J Am Coll Cardiol 2015;65:1161–71.
[27] Yamamoto K, Sakakura K, Akashi N, Watanabe Y, Noguchi M, Taniguchi Y, et al. Clinical outcomes after acute myocardial infarction according to a novel stratification system linked to a rehabilitation program. J Cardiol 2018;72:227–33.
[28] Afilalo J, Alexander KP, Mack MJ, Maurer MS, Green P, Allen LA, et al. Frailty assessment in the cardiovascular care of older adults. J Am Coll Cardiol 2014;63:747–62.
[29] Nochioka K, Sakata Y, Takahashi J, Miyata S, Miura M, Takada T, et al. Prognostic impact of nutritional status in asymptomatic patients with cardiac diseases. Circ J 2013;77:2318–26.
[30] Shimokawa H, Miura M, Nochioka K, Sakata Y. Heart failure as a general pandemic in Asia. Eur J Heart Fail 2015;17:884–92.
[31] Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, et al. Heart disease and stroke statistics - 2018 update: a report from the American Heart Association. Circulation 2018;137:e67–492.
[32] Shiba N, Nochioka K, Miura M, Kohno H, Shimokawa H, on behalf of the CHART-2 Investigators. Trend of Westernization of etiology and clinical characteristics of heart failure patients in Japan. Circ J 2011;75:823–33.