Original Article

Elderly Asian Patients Have Lower Revascularisation Rates and Poorer Outcomes for ST-Elevation Myocardial Infarction Compared to Younger Patients

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Abstract

Introduction: There is limited information on elderly patients presenting with ST-elevation myocardial infarction (STEMI). This study aimed to study the outcomes of elderly Asian patients with STEMI compared to younger patients. Materials and Methods: The study utilised data from 2007 to 2012 from the Singapore Myocardial Infarction Registry, a mandatory national population-based registry. Elderly patients were defined as ≥80 years of age, middle-aged to old (MAO) patients were defined as 45–80 years of age and young patients were defined as ≤45 years of age. The primary outcome of the study was 1-year mortality and secondary outcomes included in-hospital complications and mortality. Results: There were 12,409 STEMI patients with 1207 (9.7%) elderly patients, 10,093 (81.3%) MAO patients and 1109 (8.9%) young patients. Elderly patients had more cardiovascular risk factors and lower rates of total percutaneous coronary intervention (26.0% vs 72.4% vs 85.5%, respectively; *P* <0.0001) compared to MAO and young patients. They had higher 1-year mortality (60.6% vs 18.3% vs 4.1%, respectively; *P* <0.0001) when compared to MAO and young patients. Conclusion: Elderly patients with STEMI have poorer outcomes than MAO and young patients. This is potentially attributable to a myriad of factors including age, higher burden of comorbidities and a lesser likelihood of receiving revascularisation and guideline-recommended medical therapy.

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Key words: Coronary artery bypass graft, Percutaneous coronary intervention

Introduction

ST-elevation myocardial infarction (STEMI) has been well studied in many real-world populations but there are limited data on patients at the extremes of ages.[1,2] Age is a major risk factor of ischaemic heart disease.[3] In developed countries with an ageing population, the prevalence of the elderly presenting with STEMI is increasing.[4–6] Elderly patients have more comorbidities and primary percutaneous coronary intervention (PCI) in the elderly has also been associated with increased morbidity and mortality.[6–9] Regardless, elderly patients still benefit from revascularisation when indicated.[10–13] On the other hand, patients aged ≤45 years old—while uncommon—represent a significant minority of patients with STEMI, with an incidence ranging from 2–10%.[14–16] Young patients have been described to have a different risk profile from the normal population—with obesity and smoking being more prevalent[15–18] and ethnic differences previously described in Asian populations.[19,20] Young patients have also been described to have better in-hospital and long-term outcomes

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with lower mortality and morbidity rates.[14–17] This study aimed to describe the clinical characteristics, in-hospital and long-term outcomes of elderly patients aged ≥80 years old with STEMI and young patients aged ≤45 years old when compared to middle-aged to old (MAO) patients aged 45–80 years old. We hypothesised that elderly patients with STEMI will have lower rates of revascularisation and poorer outcomes as compared to MAO and young patients.

Materials and Methods

Data Sources

The study utilised data from 2007 to 2012 from the Singapore Myocardial Infarction Registry (SMIR), a national population-based registry coordinated by the National Registry of Diseases Office (NRDO). Singapore's NRDO was established in 2001. It is a state-mandated reporting programme that collects data on key non-communicable diseases such as acute myocardial infarction (AMI), stroke, end-stage renal failure and cancer. All Singapore residents have a unique National Registration Identity Card (NRIC) number, which allows tracking of mortality and hospital admissions. The study utilised AMI, stroke and death data from the NRDO from 2007 to 2012. Data on clinical outcomes were collected until 2014. Index events of AMI were identified and the data collected is described below. The study was confined to Singapore residents (citizens and permanent residents).

The SMIR[21] is a part of the NRDO that collects data on all AMI in Singapore. All hospitals are legally required to report AMI cases to this registry. In summary, demographics, clinical characteristics and outcomes (death, AMI and strokes) for index patients in the registry are obtained from various sources, which include MediClaim listings from the Ministry of Health, Hospital In-patient Discharge Summary (HIDS), cardiac biomarkers from laboratories and death data from the Registry of Births and Deaths of the Ministry of Home Affairs. These different sources of data provide near 100% coverage of AMI notifications.

Name lists from MediClaims, HIDS and the Death Registry were merged using the patients' NRIC number to derive the master patient list, from which the patient list for each hospital was generated. Cases extracted from MediClaims, HIDS and the Death Registry were coded based on the International Classification of Diseases 9th Revision (ICD-9 Clinical Modification).[22] ICD-9 code 410 was used for STEMI cases diagnosed in 2007 to 2011 while ICD-10 codes I21 and l22 were used for STEMI cases diagnosed in 2012 to 2013. A team of registry coordinators, comprising trained nurses reviewed each case on-site at every hospital to ensure data accuracy. Once the cases were verified, data was captured from electronic medical records and case notes, and entered into the electronic registry forms. STEMI cases were identified through the same process. Recurrence of AMI after 28 days of a recorded AMI episode was counted as another episode. To ensure data accuracy of at least 95% and inter-rater reliability (Kappa coefficient) of ≥75%, a separate team of qualified nurses was tasked to perform an annual audit of the data.

Study Population

The study utilised data from all STEMI patients in the SMIR from 2007 to 2012. The patients were arbitrarily divided into 3 different age groups. Young patients were defined as patients ≤45 years of age, MAO patients were defined as 45–80 years of age and elderly patients were defined as ≥80 years of age (with the age of patients rounded down to the nearest whole number).

Outcomes

The primary outcome of the study was 1-year mortality. Secondary outcomes included 2-year mortality and in-hospital complications such as heart failure, arrhythmia and stroke.

Statistical Analysis

Clinical characteristics were compared between the young, MAO and elderly patient groups using Kruskal-Wallis equality-of-populations rank or chi-square test as appropriate. Survival time was measured from index hospital admission for STEMI to the date of all-cause death or date of censor (31 December 2014). Univariate Cox regression models were used to assess the significance of clinical predictors (demographics, risk factors and clinical presentation) for 1-year mortality. Adjusted Cox regression models were analysed with variables that have P value <0.05 from univariate analysis. The hazard ratios for death and their corresponding 95% confidence intervals were derived by Cox regression. This was done for all patients and separately for 3 age groups. Unadjusted Kaplan-Meier survival curve was plotted for 1-year mortality comparing the 3 age groups. Stata Version 13 software was used for the analysis.

The Institutional Review Board waived the requirement for ethics approval. The data utilised for this study was non-identifiable as it was collected and integrated by NRDO.

Results

There were 12,409 STEMI patients recorded between 2007 and 2012. Of these, there were 1207 (9.7%) elderly, 10,093 (81.3%) MAO and 1109 (8.9%) young patients. Table 1 shows the key demographic and clinical characteristics of the 3 groups. Compared to MAO and young patients,

elderly patients had more cardiovascular risk factors such as hypertension, diabetes mellitus, having previous AMI or coronary artery bypass graft (CABG) (all: P <0.0001). However, they had lower rates of smoking compared to MAO and young patients (26.4% vs 56.8% vs 75.2%, respectively; P<0.0001), as well as lower median body mass index (BMI) (21.7 vs 24.5 vs 26.6, respectively; P = 0.0001).

Table 2 describes the treatment modalities in the 3 age groups, with fewer elderly patients undergoing revascularisation with PCI, CABG or thrombolysis compared to MAO and young patients. Table 3 shows the rate of in-hospital outcomes. Elderly patients had higher rates of in-hospital complications such as heart failure, atrial fibrillation, acute renal failure and strokes compared to MAO and young patients (all: P<0.0001). They also had significantly higher in-hospital mortality (38.5% vs 11.2% vs 2.17%, respectively; P <0.0001).

Multivariate independent predictors of 1-year mortality of young, MAO and elderly patients are listed in Table 4. The full details of the independent predictors of 1-year mortality are found in Supplementary Tables 1–4. Renal impairment was a significant independent predictor of 1-year mortality in the elderly, MAO and young patients (hazard ratio [HR] 1.0017, 95% confidence interval [CI] 1.0007–1.0028; HR 1.0006, 95% CI 1.0001–1.0010; HR 1.01, 95% CI 1.00–1.02; respectively). Statin usage was

Table 1. Characteristics of Study Population

Variable	Young Patients (n = 1109)	Middle-Aged to Old Patients (n = 10,093)	Elderly Patients (n = 1207)	Total (n = 12,409)	*P* Value
Demographics					
Male, n (%)	1035 (93.3)	8161 (80.9)	482 (39.9)	9678 (78.0)	<0.0001
Age (years, mean ± SD)	39.8 ± 4.1	60.7 ± 9.6	86.2 ± 4.3	61.3 ± 13.4	<0.0001
Length of stay (days, mean ± SD)	4.7 ± 9.5	6.5 ± 10.3	9.4 ± 13.2	6.6 ± 10.6	0.0001
Ethnicity, n (%)					<0.0001
Chinese	584 (52.7)	6495 (64.4)	978 (81.0)	8057 (64.9)	
Malay	235 (21.2)	2041 (20.2)	124 (10.3)	2400 (19.3)	
Indian	267 (24.1)	1406 (13.9)	87 (7.2)	1760 (14.2)	
Others	23 (2.1)	151 (1.5)	18 (1.5)	192 (1.6)	
Median BMI (kg/m^2) (IQR)	26.2 (23.9 – 29.2)	24.2 (22.0 – 26.7)	21.3 (18.7 – 24.3)	24.2 (21.8 – 26.8)	0.0001
Risk factors, n (%)					
Hypertension	404 (36.4)	5684 (56.3)	856 (70.9)	6944 (56.0)	<0.0001
Diabetes mellitus	197 (17.8)	3350 (33.2)	402 (33.3)	3949 (31.8)	<0.0001
Hyperlipidaemia	333 (30.0)	4666 (46.2)	529 (43.8)	5528 (44.6)	<0.0001
Previous AMI	63 (5.7)	1102 (10.9)	196 (16.2)	1364 (11.0)	<0.0001
Previous CABG	1 (0.1)	172 (1.7)	27 (2.2)	200 (1.6)	<0.0001
Previous PCI	55 (5.0)	745 (7.4)	47 (3.9)	847 (6.8)	<0.0001
Ever smoker	834 (75.2)	5733 (56.8)	319 (26.4)	6886 (55.5)	<0.0001
Killip class on admission, n (%)					<0.0001
I	1013 (91.3)	7938 (78.7)	799 (66.2)	9750 (78.6)	
II	36 (3.3)	872 (8.6)	186 (15.4)	1094 (8.8)	
III	17 (1.5)	515 (5.1)	107 (8.9)	639 (5.2)	
IV	40 (3.6)	679 (6.7)	90 (7.5)	809 (6.5)	
Territory, n (%)					
Anterior	573 (51.7)	5414 (53.6)	721 (59.7)	6708 (54.1)	<0.0001
Inferior	508 (45.8)	4389 (43.5)	415 (34.4)	5312 (42.8)	<0.0001
Lateral	132 (11.9)	1205 (11.9)	149 (12.3)	1486 (12.0)	0.92
Right ventricular	57 (5.1)	681 (6.8)	51 (4.2)	789 (6.4)	0.001
Posterior	135 (12.2)	1402 (13.9)	136 (11.3)	1673 (13.5)	0.017

ACE: Angiotension converting enzyme; AMI: Acute myocardial infarction; BMI: Body mass index; CABG: Coronary artery bypass graft; IQR: Interquartile range; PCI: Percutaneous coronary intervention; SD: Standard deviation

Table 1. Characteristics of Study Population (Cont'd)

Variable	Young Patients (n = 1109)	Middle-Aged to Old Patients (n = 10,093)	Elderly Patients (n = 1207)	Total (n = 12,409)	*P* Value
Median laboratory data (IQR)					
Troponin T peak (ng/mL)	3.7 (1.4 – 7.4)	3.4 (1.02 – 8.2)	1.7 (0.5 – 5.1)	3.3 (1.0 – 7.9)	0.0001
Troponin I peak (ng/mL)	54.2 (18.3 – 80)	49.8 (11.8 – 80)	36.1 (4.7 – 80)	46.2 (11.0 – 80)	0.0001
High-density lipoprotein (mmol/L)	0.9 (0.8 – 1.1)	1.0 (0.8 – 1.2)	1.1 (0.9 – 1.4)	1.0 (0.8 – 1.2)	0.0001
Low-density lipoprotein (mmol/L)	3.6 (3.0 – 4.4)	3.3 (2.6 – 4.1)	2.6 (2.0 – 3.3)	3.3 (2.6 – 4.1)	0.0001
Triglycerides (mmol/L)	1.7 (1.2 – 2.5)	1.3 (1.0 – 1.9)	1.0 (0.8 – 1.4)	1.3 (1.0 – 1.9)	0.0001
Haemoglobin A1c (%)	6.3 (5.6 – 9.1)	6.4 (5.8 – 8.2)	6.2 (5.6 – 6.9)	6.4 (5.7 – 8.2)	0.0001
Haemoglobin (g/dL)	15.4 (14.4 – 16.3)	14.3 (13.0 – 15.4)	11.9 (10.4 – 13.3)	14.3 (12.8 – 15.4)	0.0001
Creatinine (µmol/L)	86 (74 – 99)	93 (78 – 116)	115 (84 – 171)	93.0 (78 – 117)	0.0001
Discharge medications, n (%)					
Aspirin	1014 (94.8)	8229 (93.8)	517 (75.2)	9760 (92.6)	<0.0001
Beta-blocker	963 (90.0)	7582 (86.4)	486 (70.6)	9031 (85.7)	<0.0001
ACE inhibitor	789 (73.7)	6548 (74.6)	407 (59.2)	7744 (73.5)	<0.0001
Statin	1038 (97.0)	8355 (95.2)	592 (86.1)	9985 (94.8)	<0.0001

ACE: Angiotension converting enzyme; AMI: Acute myocardial infarction; BMI: Body mass index; CABG: Coronary artery bypass graft; IQR: Interquartile range; PCI: Percutaneous coronary intervention; SD: Standard deviation

Table 2. Treatment Modalities

Variable	Young Patients (n = 1109)	Middle-Aged to Old Patients (n = 10,093)	Elderly Patients (n = 1207)	Total (n = 12,409)	*P* Value
Percutaneous coronary intervention, n (%)					
Total	948 (85.5)	7303 (72.4)	314 (26.0)	8565 (69.0)	<0.0001
Primary	802 (72.3)	6254 (62.0)	279 (23.1)	7335 (59.1)	<0.0001
Rescue/staged	170 (15.3)	1236 (12.3)	41 (3.4)	1447 (11.7)	<0.0001
Thrombolysis	47 (4.2)	431 (4.3)	28 (2.3)	506 (4.1)	0.005
Coronary artery bypass graft, n (%)					
Total	15 (1.4)	299 (3.0)	2 (0.2)	316 (2.6)	<0.0001
Urgent	2 (0.2)	34 (0.3)	0	36 (0.3)	<0.0001
Elective	13 (1.2)	265 (2.6)	2 (0.2)	280 (2.3)	<0.0001
Medical therapy	128 (11.5)	2391 (23.7)	869 (72.0)	3388 (27.3)	<0.0001

Table 3. In-Hospital Outcomes

Variable	Young Patients (n = 1109)	Middle-Aged to Old Patients (n = 10,093)	Elderly Patients (n = 1207)	Total (n = 12,409)	*P* Value
Heart failure, n (%)	79 (7.1)	1567 (15.5)	330 (27.4)	1976 (15.9)	<0.0001
Atrial fibrillation/flutter, n (%)	47 (4.2)	1079 (10.7)	301 (24.9)	1427 (11.5)	<0.0001
Ventricular fibrillation/ sustained ventricular tachycardia, n (%)	79 (7.1)	932 (9.2)	87 (7.2)	1098 (8.9)	0.007
Acute renal failure, n (%)	22 (2.0)	690 (6.8)	193 (16.0)	905 (7.3)	<0.0001
Stroke, n (%)	7 (0.6)	176 (1.7)	29 (2.4)	212 (1.7)	0.004
Ischaemic	4 (0.3)	147 (1.4)	23 (1.9)	174 (1.4)	0.004
Haemorrhagic	3 (0.3)	27 (0.3)	5 (0.4)	35 (0.3)	0.66
Left ventricular ejection fraction <50%, n (%)	587 (52.9)	5877 (58.2)	613 (50.8)	7077 (57.0)	0.0001
In-hospital mortality, n (%)	30 (2.7)	1131 (11.2)	465 (38.5)	1626 (13.1)	<0.0001

an independent protective factor amongst all 3 age groups (HR 0.47, 95% CI 0.34–0.65; HR 0.48, 95% CI 0.38–0.61; HR 0.04, 95% CI 0.007–0.25; respectively).

Figure 1 shows the long-term mortality outcomes between the 3 age groups with elderly patients having significantly higher 30-day, 1-year and 2-year mortality compared to MAO and young patients. The survival curve of patients with STEMI compared amongst the 3 age groups is shown in Figure 2. The significant univariate and multivariate predictors of 1-year mortality of the total cohort and each age group is described in Supplementary Tables 1 to 4.

Table 4. Independent Predictors and Protective Factors of 1-Year Mortality

Independent Predictor	**Hazard Ratio**	**95% Confidence Interval**
Young patients (n = 1109)		
Creatinine (per µmol/L)	1.01	1.00 – 1.02
Middle-aged to old patients (n = 10,093)		
Age (per year)	1.049	1.038 – 1.060
Creatinine (per µmol/L)	1.0006	1.0001 – 1.0010
Malay ethnicity	1.26	1.02 – 1.55
Hypertension	1.34	1.08 – 1.67
Diabetes mellitus	1.46	1.21 – 1.76
Killip class III heart failure	1.75	1.34 – 2.29
Killip class IV heart failure	1.52	1.04 – 2.23
Elderly patients (n = 1207)		
Previous AMI	1.98	1.45 – 2.72
Killip Class II heart failure	1.44	1.03 – 2.02
Creatinine (per µmol/L)	1.0017	1.0007 – 1.0028
Independent Protective Factor	**Hazard Ratio**	**95% Confidence Interval**
Young patients (n = 1109)		
Prescribed statin on discharge	0.04	0.007 – 0.25
Middle-aged to old patients (n = 10,093)		
Haemoglobin (per g/dL)	0.89	0.86 – 0.93
Treatment: PCI only	0.45	0.36 – 0.55
Treatment: CABG only	0.36	0.18 – 0.74
Treatment: mixed revascularisation*	0.27	0.15 – 0.48
Prescribed aspirin on discharge	0.65	0.52 – 0.83
Prescribed beta-blocker on discharge	0.71	0.58 – 0.88
Prescribed ACE inhibitor on discharge	0.72	0.60 – 0.87
Prescribed statin on discharge	0.48	0.38 – 0.61
Elderly patients (n = 1207)		
Treatment: PCI only	0.44	0.30 – 0.64
Prescribed aspirin on discharge	0.68	0.50 – 0.92
Prescribed statin on discharge	0.47	0.34 – 0.65

ACE: Angiotensin converting enzyme; CABG: Coronary artery bypass graft; PCI: Percutaneous coronary intervention
*Refers to either PCI, CABG or thrombolysis.

Discussion

In this study, we sought to investigate and understand the differences in presentation, clinical characteristics, treatment received and outcomes in the different age groups of patients. The findings showed significant differences in the various groups and shed important light on the variability in the extremes of age in this cohort.

The distribution of risk factors varies significantly amongst the 3 groups. The young had a significantly lower prevalence of cardiovascular risk factors as compared to older patients—with the exception of smoking, hyperlipidaemia and higher BMI—which is consistent with studies in Japan.[18] Smoking and hyperlipidaemia are known risk factors for coronary atherosclerosis in the young.[23] These risk factors are modifiable and represent an opportunity for public health interventions to prevent cardiovascular disease in the young.

In our study, there was a lower rate of PCI amongst the elderly as compared to MAO and young patients (26.0% vs 72.4% vs 85.5%, respectively; P <0.0001). This lower rate of revascularisation in the elderly is well described in both Western and Asian populations.[24–26] Other studies

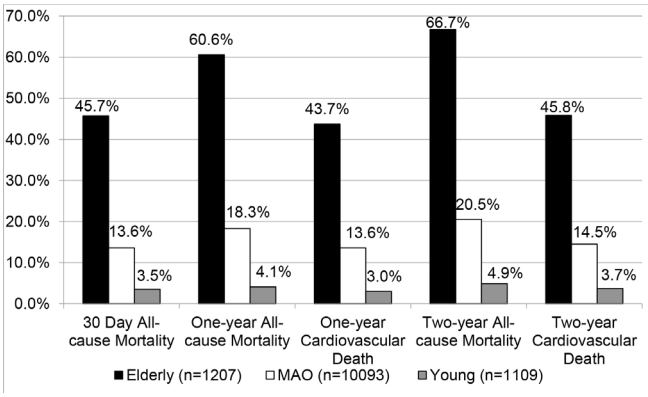

Fig. 1. Graph showing mortality outcomes by age group.

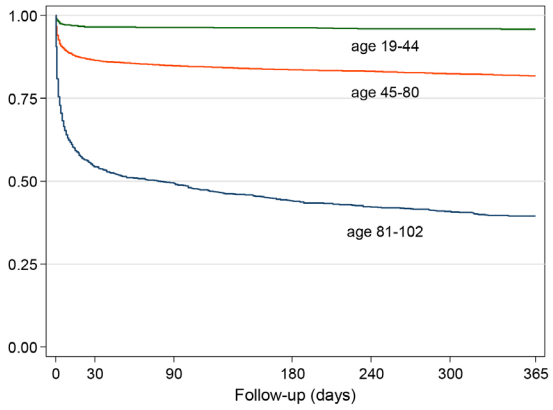

Fig. 2. Graph showing survival curves by age groups.

suggested reasons for this trend such as the elderly having delayed diagnosis due to atypical symptoms and abnormal resting electrocardiograms or comorbidities that are contraindications to reperfusion.[27,28] Current guidelines recommend coronary revascularisation as standard of care for STEMI in elderly patients.[10,12] Revascularisation in the elderly has mortality benefit and improves quality of life. The Alberta Provincial Project for Outcomes Assessment in Coronary Heart Disease study demonstrated that elderly patients undergoing revascularisation had greater absolute risk reductions in mortality at 4 years,[29] as well as improved quality of life at 1 and 3 years, when compared to younger patients.[30] Supporting this, PCI was an independent negative predictor of 1-year mortality in the elderly (HR 0.44, 95% CI 0.30–0.64) in our study. There is room to study the reasons why the rates of guideline-recommended revascularisation are lower in the elderly.

In this study, the rate of PCI per STEMI in the elderly is similar to that of other countries. PCI per STEMI ranged from 19.7% (in 2007) to 31.2% (in 2010) in the Nation-wide Inpatient Sample (NIS) of the United States[24] compared to an average of 26.0% in our study (2007– 2012). In Singapore, there are additional reasons influencing the decision for revascularisation such as the conservative attitudes of patients towards healthcare. A national survey of senior citizens in Singapore revealed that 10% of the elderly had financial concerns as a reason for not seeing a doctor when ill and that 44.8% of elderly were not financially independent when paying for healthcare expenses.[31] Another local study showed that elderly citizens' top fear about dying was high medical cost (88%) and being a financial burden to family (87%).[32] These financial concerns could be a barrier to choosing PCI as a treatment strategy for elderly patients in Singapore.

In terms of medical therapy, the elderly also received less guideline-recommended medications on discharge such as aspirin, beta-blockers and angiotensin converting enzyme (ACE) inhibitors as compared to younger patients. These results are consistent with the large multinational Global Registry of Acute Coronary Events.[33] Postulated reasons for using less antihypertensive agents such as beta-blockers and ACE inhibitors include contraindications such as hypotension and renal impairment. The higher prevalence of acute renal failure (16.0%) in the elderly in this study could have hindered the use of ACE inhibitors. Elderly patients had lower mean haemoglobin as compared to MAO and young patients (11.8 vs 14.0 vs 15.3 g/dL, respectively; P <0.0001) and the high prevalence of anaemia could have hindered the prescription of aspirin. An American study of 10,018 elderly patients with AMI revealed that one-third of elderly patients did not receive aspirin within the first 2 days of hospitalisation, with those taking aspirin having a 22% lower 30-day mortality.[34] In Japan, a study of elderly patients undergoing PCI also revealed that the use of dual antiplatelet therapy and statin therapy was lower in the elderly compared to younger patients.[35]

On multivariate analysis, after adjusting for confounders, age remained a significant predictor of 1-year mortality in the overall cohort. Elderly patients have worse in-hospital outcomes as compared to MAO and young patients with higher rates of in-hospitality mortality (38.5% vs 11.2% vs 2.7%, respectively; P <0.0001), renal failure (16.0% vs 6.8% vs 2.0%, respectively; P <0.0001) and stroke (2.4% vs 1.7% vs 0.6%, respectively; P <0.0004). In the NIS, octogenarian patients with STEMI also had higher in-hospital mortality, acute renal failure and stroke compared to patients aged 65–79 years of age.[24]

In the MAO age group, independent predictors of 1-year mortality include classic cardiovascular risk factors such as age, hypertension, diabetes mellitus, renal impairment and Killip III/IV heart failure, as well as previously described protective factors such as treatment with PCI, CABG and guideline-recommended medical therapy. Elderly patients have fewer independent risk factors and protective factors for 1-year mortality. It is possible that the impact of age as a risk factor on 1-year mortality outweighs the other classic cardiovascular risk factors and protective factors. In terms of the protective effect of guideline-recommended medical therapy on 1-year mortality, the elderly benefited similarly from aspirin and statin on discharge compared to MAO patients. Beneficial effects of statin therapy on mortality has been shown in elderly patients with coronary artery disease with greater absolute risk reductions in elderly patients >80 years of age.[36] Further work is needed on the differences in response to antiplatelet and statin therapy in elderly Asians.

Guideline-recommended medical therapy such as beta-blockers and ACE inhibitors were not independent protective factors of 1-year mortality in the elderly. The reduced effect of beta-blockers in advancing age has been previously described, with greater mortality reductions in younger patients compared to older patients.[37]

Within the elderly age group, there were several independent predictors of mortality such as having previous AMI, Killip Class II heart failure and renal impairment. This agrees with a large multicentre study where heart failure and renal impairment were shown to be independent predictors of in-hospital mortality in elderly patients.[24] In the young, there were few independent predictors of 1-year mortality that reached significance because of the low mortality rate.

Limitations

Our study has several limitations. First, the study utilised data from SMIR which is a retrospective, observational registry. However, data collection is state-mandated and audited for clinical accuracy. Second, the SMIR does not systemically collect reasons on why a patient does not undergo revascularisation. This limited the ability of our study to explain why revascularisation rates are so low in the elderly population.

Conclusion

Elderly patients with STEMI have poorer outcomes than MAO and young patients. This is potentially attributable to a myriad of factors including age, higher burden of comorbidities and a lesser likelihood of receiving revascularisation and guideline-recommended medical therapy. The results of this study reinforce the need for physicians to continue prescribing guideline-recommended medical therapy to the elderly and to consider revascularisation in suitable patients without excluding the elderly based on advanced age alone. Further studies will need to be conducted to examine the reasons behind the lower rates of revascularisation and medical therapy in the elderly.

Financial Disclosure

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Supplementary Table 1. Significant Univariate and Multivariate Predictors of 1-Year Mortality in Overall Cohort

Patients (n = 12,409)	**Unadjusted Hazard Ratio, 95% Confidence Interval**		**Adjusted Hazard Ratio Model Without Discharge Medication**		**Adjusted Hazard Ratio Model With Discharge Medication**	
	Hazard Ratio	**95% Confidence Interval**	**Hazard Ratio**	**95% Confidence Interval**	**Hazard Ratio**	**95% Confidence Interval**
Male gender	0.37	0.34 – 0.40	0.89	0.80 – 0.99	0.83	0.69 – 1.00
Age, years						
18 – 44	Reference		Reference		Reference	
45 – 80	4.73	3.53 – 6.34	2.74	1.97 – 3.81	3.30	1.81 – 6.03
81 – 102	20.5	15.2 – 27.6	5.22	3.71 – 7.36	6.99	3.74 – 13.06
Ethnicity						
Chinese	Reference		Reference		Reference	
Malay	0.94	0.85 – 1.03	1.05	0.94 – 1.17	1.20	1.00 – 1.44
Indian	0.63	0.56 – 0.72	0.89	0.77 – 1.02	0.95	0.75 – 1.20
Others	0.69	0.48 – 0.98	1.03	0.70 – 1.51	0.79	0.38 – 1.68
Risk factors						
Hypertension	1.70	1.57 – 1.85	1.09	0.99 – 1.21	1.24	1.03 – 1.49
Diabetes mellitus	1.69	1.57 – 1.82	1.20	1.10 – 1.32	1.43	1.22 – 1.67
Hyperlipidaemia	1.07	0.99 – 1.15	NA	NA	NA	NA
Previous AMI	1.72	1.55 – 1.91	1.29	1.14 – 1.46	1.34	1.08 – 1.65
Previous CABG	1.85	1.47 – 2.34	1.12	0.87 – 1.44	1.07	0.69 – 1.64
Previous PCI	0.83	0.71 – 0.98	0.89	0.74 – 1.08	1.17	0.88 – 1.56
Ever smoker	0.52	0.48 – 0.57	0.98	0.89 – 1.09	1.10	0.93 – 1.31

ACE: Angiotensin converting enzyme; AMI: Acute myocardial infarction; CABG: Coronary artery bypass graft; NA: Not applicable; PCI: Percutaneous coronary intervention

Supplementary Table 1. Significant Univariate and Multivariate Predictors of 1-Year Mortality in Overall Cohort (Cont'd)

Patients (n = 12,409)	Unadjusted Hazard Ratio, 95% Confidence Interval		Adjusted Hazard Ratio Model Without Discharge Medication		Adjusted Hazard Ratio Model With Discharge Medication	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Killip class on admission						
I	Reference		Reference		Reference	
II	2.10	1.86 – 2.37	1.11	0.98 – 1.26	1.41	1.16 – 1.72
III	3.11	2.73 – 3.55	1.50	1.30 – 1.73	1.61	1.28 – 2.03
IV	4.92	4.42 – 5.48	4.50	3.99 – 5.07	1.55	1.11 – 2.17
Territory – anterior	1.25	1.15 – 1.35	1.12	1.03 – 1.22	1.14	0.98 – 1.33
Haemoglobin (per g/dL)	0.74	0.73 – 0.75	0.88	0.86 – 0.90	0.88	0.85 – 0.91
Creatinine (per µmol)	1.002	1.0019 – 1.0023	1.0008	1.0006 – 1.0010	1.0007	1.0003 – 1.0011
Treatment modality						
Medical	Reference		Reference		Reference	
PCI only	0.15	0.14 – 0.16	0.27	0.24 – 0.30	0.37	0.31 – 0.44
CABG only	0.23	0.16 – 0.34	0.32	0.21 – 0.48	0.32	0.16 – 0.65
Mixed revascularisation	0.17	0.13 – 0.21	0.34	0.26 – 0.43	0.23	0.14 – 0.40
Prescribed on discharge						
Aspirin	0.18	0.15 – 0.21	NA	NA	0.68	0.56 – 0.83
Beta-blocker	0.41	0.35 – 0.48	NA	NA	0.74	0.62 – 0.88
ACE inhibitor	0.45	0.39 – 0.52	NA	NA	0.76	0.65 – 0.89
Statin	0.18	0.15 – 0.22	NA	NA	0.46	0.38 – 0.55

ACE: Angiotensin converting enzyme; AMI: Acute myocardial infarction; CABG: Coronary artery bypass graft; NA: Not applicable; PCI: Percutaneous coronary intervention

Supplementary Table 2. Significant Univariate and Multivariate Predictors of 1-Year Mortality in Young Patients

Patients (n = 1109)	Unadjusted Hazard Ratio, 95% Confidence Interval		Adjusted Hazard Ratio Model Without Discharge Medication		Adjusted Hazard Ratio Model With Discharge Medication	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Male gender	0.28	0.14 – 0.58	0.72	0.26 – 1.99	1.62	0.13 – 19.8
Age, years	1.04	0.96 – 1.13	NA	NA	NA	NA
Ethnicity						
Chinese	Reference		Reference		Reference	
Malay	1.89	0.97 – 3.69	1.50	0.64 – 3.51	2.14	0.32 – 14.2
Indian	0.87	0.38 – 1.98	1.10	0.43 – 2.79	2.75	0.49 – 15.5
Others	3.88	1.15 – 13.1	4.85	1.31 – 17.9	12.2	0.94 – 157.4
Risk factors						
Hypertension	1.23	0.68 – 2.21	NA	NA	NA	NA
Diabetes mellitus	2.26	1.22 – 4.20	1.59	0.71 – 3.60	1.93	0.44 – 8.40
Hyperlipidaemia	1.03	0.55 – 1.93	NA	NA	NA	NA
Previous AMI	1.18	0.37 – 3.79	NA	NA	NA	NA
Previous CABG	42.23	5.73 – 311.2	NA	NA	NA	NA
Previous PCI	NA	NA	NA	NA	NA	NA
Ever smoker	0.34	0.18 – 0.65	0.42	0.20 – 0.88	0.32	0.08 – 1.29

ACE: Angiotensin converting enzyme; AMI: Acute myocardial infarction; CABG: Coronary artery bypass graft; NA: Not applicable; PCI: Percutaneous coronary intervention

Supplementary Table 2. Significant Univariate and Multivariate Predictors of 1-Year Mortality in Young Patients (Cont'd)

Patients (n = 1109)	Unadjusted Hazard Ratio, 95% Confidence Interval		Adjusted Hazard Ratio Model Without Discharge Medication		Adjusted Hazard Ratio Model With Discharge Medication	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Killip class on admission						
I	Reference		Reference		Reference	
II	2.09	0.50 – 8.77	1.25	0.28 – 5.57	3.23	0.48 – 21.9
III	7.31	2.22 – 24.1	6.54	1.80 – 23.8	NA	NA
IV	12.0	5.93 – 24.1	10.6	4.64 – 24.3	NA	NA
Territory – anterior	1.96	1.06 – 3.62	1.84	0.88 – 3.85	2.07	0.50 – 8.65
Haemoglobin (per g/dL)	0.73	0.65 – 0.82	0.90	0.76 – 1.08	0.86	0.58 –1.27
Creatinine (per µmol)	1.0024	0.0015 – 1.0034	1.0051	1.0020 – 1.0082	1.01	1.00 – 1.02
Treatment modality						
Medical	Reference		Reference		Reference	
PCI only	0.21	0.11 – 0.38	0.59	0.26 – 1.36	1.65	0.25 – 10.7
CABG only	0.64	0.09 – 4.84	0.43	0.04 – 4.28	NA	NA
Mixed (including thrombolysis)	0.14	0.02 – 1.04	0.46	0.05 – 3.90	NA	NA
Prescribed on discharge						
Aspirin	0.25	0.05 – 1.13	NA	NA	NA	NA
Beta-blocker	0.19	0.06 – 0.65	NA	NA	0.53	0.11 – 2.66
ACE inhibitor	0.29	0.09 – 0.96	NA	NA	0.32	0.08 – 1.23
Statin	0.08	0.02 – 0.30	NA	NA	0.04	0.007 – 0.25

ACE: Angiotensin converting enzyme; AMI: Acute myocardial infarction; CABG: Coronary artery bypass graft; NA: Not applicable; PCI: Percutaneous coronary intervention

Supplementary Table 3. Significant Univariate and Multivariate Predictors of 1-Year Mortality in Middle-Aged to Old Patients

Patients (n = 10,093)	Unadjusted Hazard Ratio, 95% Confidence Interval		Adjusted Hazard Ratio Model Without Discharge Medication		Adjusted Hazard Ratio Model With Discharge Medication	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Male gender	0.44	0.40 – 0.48	0.97	0.85 – 1.11	0.86	0.69 – 1.07
Age, years	1.073	1.068 – 1.078	1.046	1.039 – 1.052	1.049	1.038 – 1.060
Ethnicity						
Chinese	Reference		Reference		Reference	
Malay	1.12	1.00 – 1.25	1.08	0.96 – 1.22	1.26	1.02 – 1.55
Indian	0.76	0.65 – 0.88	1.01	0.86 – 1.20	1.08	0.82 – 1.41
Others	0.69	0.44 – 1.07	1.12	0.69 – 1.81	0.98	0.44 – 2.21
Risk factors						
Hypertension	1.61	1.46 – 1.77	1.04	0.93 – 1.18	1.34	1.08 – 1.67
Diabetes mellitus	1.78	1.62 – 1.95	1.22	1.09 – 1.36	1.46	1.21 – 1.76
Hyperlipidaemia	1.07	0.98 – 1.17	NA	NA	NA	NA
Previous AMI	1.61	1.42 – 1.83	1.13	0.99 – 1.30	1.18	0.93 – 1.50
Previous CABG	1.89	1.45 – 2.47	1.24	0.93 – 1.65	1.17	0.72 – 1.92
Previous PCI	0.90	0.75 – 1.08	-		-	
Ever smoker	0.62	0.56 – 0.68	1.02	0.91 – 1.15	1.21	0.98 – 1.48

ACE: Angiotensin converting enzyme; AMI: Acute myocardial infarction; CABG: Coronary artery bypass graft; NA: Not applicable; PCI: Percutaneous coronary intervention

Supplementary Table 3. Significant Univariate and Multivariate Predictors of 1-Year Mortality in Middle-Aged to Old Patients (Cont'd)

Patients (n = 1109)	Unadjusted Hazard Ratio, 95% Confidence Interval		Adjusted Hazard Ratio Model Without Discharge Medication		Adjusted Hazard Ratio Model With Discharge Medication	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Killip class on admission						
I	Reference		Reference		Reference	
II	1.91	1.64 – 2.22	1.00	0.85 – 1.17	1.26	0.99 – 1.60
III	3.39	2.91 – 3.95	1.58	1.34 – 1.87	1.75	1.34 – 2.29
IV	5.60	4.95 – 6.32	5.21	4.55 – 5.97	1.52	1.04 – 2.23
Territory – anterior	1.22	1.11 – 1.33	1.11	1.00 – 1.23	1.18	0.99 – 1.42
Haemoglobin (per g/dL)	0.75	0.74 – 0.76	0.90	0.88 – 0.93	0.89	0.86 – 0.93
Creatinine (per µmol)	1.0022	1.0020 – 1.0023	1.0009	1.0007 – 1.0012	1.0006	1.0001 – 1.0010
Treatment modality						
Medical			Reference		Reference	
PCI only	0.17	0.15 – 0.18	0.28	0.25 – 0.32	0.45	0.36 – 0.55
CABG only	0.27	0.18 – 0.40	0.33	0.22 – 0.49	0.36	0.18 – 0.74
Mixed (including thrombolysis)	0.17	0.13 – 0.22	0.34	0.26 – 0.45	0.27	0.15 – 0.48
Prescribed on discharge						
Aspirin	0.19	0.16 – 0.23	NA	NA	0.65	0.52 – 0.83
Beta-blocker	0.49	0.40 – 0.59	NA	NA	0.71	0.58 – 0.88
ACE inhibitor	0.49	0.42 – 0.58	NA	NA	0.72	0.60 – 0.87
Statin	0.20	0.16 – 0.25	NA	NA	0.48	0.38 – 0.61

ACE: Angiotensin converting enzyme; AMI: Acute myocardial infarction; CABG: Coronary artery bypass graft; NA: Not applicable; PCI: Percutaneous coronary intervention

Supplementary Table 4. Significant Univariate and Multivariate Predictors of 1-Year Mortality in Elderly Patients

Patients (n = 1207)	Unadjusted Hazard Ratio, 95% Confidence Interval		Adjusted Hazard Ratio Model Without Discharge Medication		Adjusted Hazard Ratio Model With Discharge Medication	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Male gender	1.04	0.89 – 1.20	NA	NA	NA	NA
Age, years	1.042	1.025 – 1.058	1.033	1.015 – 1.051	1.020	0.988 – 1.053
Ethnicity						
Chinese	Reference		Reference		Reference	
Malay	1.05	0.83 – 1.33	NA	NA	NA	NA
Indian	0.95	0.71 – 1.25	NA	NA	NA	NA
Others	0.66	0.33 – 1.32	NA	NA	NA	NA
Risk factors						
Hypertension	0.96	0.82 – 1.13	NA	NA	NA	NA
Diabetes mellitus	1.21	1.04 – 1.41	1.13	0.97 – 1.33	1.13	0.85 – 1.50
Hyperlipidaemia	0.90	0.78 – 1.05	NA	NA	NA	NA
Previous AMI	1.31	1.09 – 1.57	1.33	1.10 – 1.60	1.98	1.45 – 2.72
Previous CABG	0.94	0.57 – 1.54	NA	NA	NA	NA
Previous PCI	0.89	0.62 – 1.30	NA	NA	NA	NA
Ever smoker	1.05	0.88 – 1.24	NA	NA	NA	NA

ACE: Angiotensin converting enzyme; AMI: Acute myocardial infarction; CABG: Coronary artery bypass graft; NA: Not applicable; PCI: Percutaneous coronary intervention

Supplementary Table 4. Significant Univariate and Multivariate Predictors of 1-Year Mortality in Elderly Patients (Cont'd)

Patients (n = 1207)	Unadjusted Hazard Ratio, 95% Confidence Interval		Adjusted Hazard Ratio Model Without Discharge Medication		Adjusted Hazard Ratio Model With Discharge Medication	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Killip class on admission						
I	Reference		Reference		Reference	
II	1.23	1.01 – 1.51	1.11	0.90 – 1.35	1.44	1.03 – 2.02
III	1.11	0.86 – 1.44	0.99	0.76 – 1.29	0.98	0.62 – 1.53
IV	2.21	1.72 – 2.83	2.35	1.81-3.05	1.51	0.73 – 3.11
Territory – anterior	1.05	0.90 – 1.22	NA	NA	NA	NA
Haemoglobin (per g/dL)	0.90	0.87 – 0.93	0.95	0.91-0.98	0.97	0.90 – 1.04
Creatinine (per µmol)	1.0013	1.0010 – 1.0017	1.0008	1.0004 – 1.0012	1.0017	1.0007 – 1.0028
Treatment modality						
Medical			Reference		Reference	
PCI only	0.39	0.31 – 0.47	0.44	0.35 – 0.54	0.44	0.30 – 0.64
CABG only	NA	NA	NA	NA	NA	NA
Mixed (including thrombolysis)	0.58	0.34 – 0.98	0.76	0.44 – 1.30	0.21	0.03 – 1.54
Prescribed on discharge						
Aspirin	0.41	0.31 – 0.54	NA	NA	0.68	0.50 – 0.92
Beta-blocker	0.62	0.47 – 0.82	NA	NA	0.84	0.63 – 1.12
ACE inhibitor	0.59	0.46 – 0.78	NA	NA	0.95	0.71 – 1.28
Statin	0.34	0.25 – 0.46	NA	NA	0.47	0.34 – 0.65

ACE: Angiotensin converting enzyme; AMI: Acute myocardial infarction; CABG: Coronary artery bypass graft; NA: Not applicable; PCI: Percutaneous coronary intervention