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Survival of Elderly Patients Undergoing Percutaneous Coronary Intervention for Acute Myocardial Infarction Complicated by Cardiogenic Shock

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Objectives We sought to assess clinical outcomes of elderly patients (age ≥75 years) undergoing percutaneous coronary intervention (PCI) for acute myocardial infarction (MI) complicated by cardiogenic shock (CS) in a contemporary multicenter PCI registry.

Background Although benefits of early PCI have been shown in younger groups, few studies have reported on clinical outcomes in elderly shock patients using current PCI techniques.

Methods We analyzed baseline characteristics and procedural and clinical outcomes in 143 consecutive patients presenting with MI and CS who underwent PCI from the Melbourne Interventional Group registry between 2004 and 2007.

Results Of the 143 patients, 31.5% (n = 45) were elderly and 68.5% were younger (age <75 years). Elderly patients were more likely to be female (46.7% vs. 22.4%, $p < 0.01$) and have hypertension (77.8% vs. 46.4%, $p < 0.01$), previous MI (31.1% vs. 15.5%, $p = 0.03$), renal failure (24.4% vs. 11.3%, $p < 0.05$) and multivessel coronary artery disease (93.1% vs. 68.3%, $p < 0.01$). Stent (86.7% vs. 94.8%, $p = 0.09$), glycoprotein IIb/IIIa inhibitor (68.9% vs. 65.3%, $p = 0.67$), and intra-aortic balloon pump (57.8% vs. 58.2%, $p = 0.97$) use were similar in both groups. In-hospital, 30-day, and 1-year mortality in the elderly group versus the younger group were 42.2% vs. 33.7% ($p = 0.32$), 43.2% vs. 36.1% ($p = 0.42$), and 52.6% vs. 46.8% ($p = 0.56$), respectively.

Conclusions In this study, the 1-year survival of elderly patients with acute MI complicated by CS undergoing PCI was comparable to younger patients. These data suggest that in elderly patients presenting with CS, benefit is possible with selective use of early revascularization and merits further investigation. (J Am Coll Cardiol Intv 2009;2:146–52) © 2009 by the American College of Cardiology Foundation

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The elderly constitute an increasing proportion of patients presenting with acute myocardial infarction (MI) (1–3), and advanced age is a strong predictor of adverse outcomes (4–6). Cardiogenic shock (CS) complicates approximately 5% to 8% of patients presenting with ST-segment elevation MI (STEMI) (7–9) and remains the leading cause of death after hospitalization (10–12). Studies have shown a benefit of percutaneous coronary intervention (PCI) in patients presenting with acute MI complicated by CS (13–16). However, in the randomized SHOCK (SHould we emergently revascularize Occluded Coronaries for cardiogenic shocK?) trial (17), the benefit of revascularization was limited to patients <75 years of age, with this subgroup analysis limited by a small number of elderly patients (17,18).

See page 153

The aim of this study was to evaluate the clinical characteristics, lesion features, procedural details, and clinical outcomes of elderly patients ≥75 years old compared with patients <75 years old undergoing PCI for acute MI complicated by CS in a large, contemporary multicenter PCI registry.

Methods

Study population. There were 3,025 patients with acute MI in the MIG (Melbourne Interventional Group) registry who underwent PCI from April 1, 2004, to December 10, 2007, including both STEMI and non-STEMI. Of these patients, 143 (4.7%) presented with CS and were categorized into 2 groups, the elderly group (age ≥75 years, n = 45), and the younger group (age <75 years, n = 98).

Data collection and registry design. The MIG registry is a collaborative PCI registry comprising 7 Australian public referral hospitals; it is designed to record prospective data of all PCI procedures. The MIG registry has been previously described in detail (19,20). Baseline demographics and clinical, angiographic, and procedural characteristics of consecutive patients undergoing PCI are prospectively recorded on case report forms using standardized definitions for all fields (20). The study protocol has been approved by the ethics committee in each participating hospital, and "opt-out" informed consent was obtained in all patients (19).

In-hospital outcomes and complications were recorded at the time of discharge. Cardiac research nurses conducted 30-day and 12-month follow-up by telephone, using a standardized questionnaire (19). All adverse events were confirmed by reviewing the patients' medical records at the relevant hospitals.

The registry is coordinated by the Centre for Cardiovascular Research & Education in Therapeutics, a research body within the Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia. An independent audit was conducted at all enrolling sites by an investigator not affiliated with that institution, in which 10 verifiable fields from 3% of all patients enrolled from each site were randomly selected and audited. Data accuracy was 97%, which is comparable to other large registries (21).

Definitions and outcomes. Acute MI was defined as STEMI or non-STEMI. We defined STEMI as the presence of at least 0.1-mV ST-segment elevation or new pathological Q waves in ≥2 contiguous electrocardiogram leads or new left bundle branch block with elevation of cardiac enzyme levels above the reference range. Non-STEMI was defined by the presence of ST-segment depression or T-wave abnormalities or ischemic symptoms with elevation of cardiac enzyme levels above the reference range.

Cardiogenic shock was defined as a systolic blood pressure of <90 mm Hg for at least 30 min or the need for supportive measures to maintain a systolic blood pressure ≥90 mm Hg associated with end-organ hypoperfusion (cool extremities or a urine output of <30 ml/h, and a heart rate of ≥60 beats/min). Hemodynamic criteria were a cardiac index of no more than 2.2 l/min/m^2 of body surface area and a pulmonary capillary wedge pressure of at least 15 mm Hg.

Abbreviations and Acronyms

CS = cardiogenic shock
MACE = major adverse cardiac events
MI = myocardial infarction
PCI = percutaneous coronary intervention
STEMI = ST-segment elevation myocardial infarction
TIMI = Thrombolysis In Myocardial Infarction
TVR = target vessel revascularization

In-hospital outcomes included all-cause mortality; periprocedural MI, defined as new MI during or after the catheterization laboratory visit with at least 1 instance of elevation of creatine kinase/creatine kinase-myocardial band more than 3 times the upper limit of normal and/or evolutionary ST-segment elevation, development of new Q waves in 2 or more contiguous electrocardiography leads, or new left bundle branch block pattern on the electrocardiogram; bleeding, defined as requiring a transfusion and/or prolonged hospital stay and/or causing a drop in hemoglobin >3.0 g/dl; congestive heart failure; renal failure, defined as an increase of creatinine to >0.20 mmol/l and 2 times the baseline creatinine level or a new requirement for dialysis; stroke; emergency PCI; and emergency coronary artery bypass graft surgery.

The 30-day and 1-year outcomes included all-cause mortality, cardiac and noncardiac deaths, MI, target lesion revascularization, and target vessel revascularization (TVR), defined as repeat revascularization within 5 mm of the treated segment and repeat revascularization of the treated vessel, respectively. Major adverse cardiac events (MACE) were a composite of death, MI, and TVR.

Statistical analysis. Continuous variables were expressed as mean ± standard deviation, and categorical data expressed as percentages, except where indicated. Continuous vari-

ables were compared using Student *t* tests or analysis of variance as appropriate. Categorical variables were compared using Fisher's exact or Pearson's chi-square tests as appropriate. All calculated p values were 2-sided and p values <0.05 were considered statistically significant. Cumulative incidence of mortality and MACE was estimated according to the Kaplan-Meier method and the log-rank test was used to evaluate differences between groups.

Univariate and multivariate logistic regression analyses were used to determine independent predictors of in-hospital mortality. Variables used were age ≥75 years, gender, diabetes mellitus, hypertension, dyslipidemia, renal failure, family history of coronary artery disease, previous MI, smoking status, STEMI, left main procedure, proximal lesions, bypass graft lesions, American College of Cardiology and American Heart Association type B2 and C lesions, ostial lesions, bifurcation lesions, use of glycoprotein IIb/IIIa inhibitors, intra-aortic balloon pump use, drug-eluting stent use, stent length ≥20 mm, and stent diameter ≤2.5 mm. All univariate predictors with $p < 0.10$, and age group were then added to a multivariate model. All statistical analyses were performed using SPSS version 15.0 for Windows (SPSS Inc., Chicago, Illinois).

Results

Baseline characteristics. The mean age of the elderly group was 79.8 ± 3.6 years and the mean age of the younger group was 61.4 ± 9.4 years. The percentage of STEMI presentations was 75.6% in the elderly group and 78.6% in the younger group. Elderly patients were more likely to be female and have hypertension, previous MI, renal failure, and multivessel coronary artery disease, as shown in Table 1. There was a trend toward more cerebrovascular disease in the elderly group. There were more current smokers in the younger group.

Among the STEMI patients, there was no significant difference in the time from symptom onset to balloon inflation or door-to-balloon time between the 2 age groups (Table 1), with a similar proportion of patients presenting very late (>24 h after onset of symptoms) in both groups.

Lesion characteristics and procedural details. There was a higher proportion of multivessel coronary artery disease in the elderly group (Table 2). There were no significant differences in the distribution of target vessel lesions and American College of Cardiology/American Heart Association lesion types. Both the elderly and the younger groups were treated with a similar proportion of stents, drug-eluting stents, glycoprotein IIb/IIIa receptor inhibitors, and intra-aortic balloon pump use. There was a similar rate of Thrombolysis In Myocardial Infarction (TIMI) flow grades 2 or 3 after the procedure.

Clinical outcomes. In-hospital, 30-day, and 1-year outcomes were available in 100%, 98.6%, and 81.8% of patients, respectively. There were 23 (16%) patients not yet eligible for 1-year follow-up at the time of analysis and 3 (2%) were lost to follow-up.

Table 1. Baseline Characteristics of the Elderly Group (Age ≥75 Years) Versus the Younger Group (Age <75 Years) Who Underwent PCI for Acute MI Complicated by CS

	Age ≥75 Yrs	Age <75 Yrs	p Value
Number of patients	45	98	
Age	79.8 ± 3.6	61.4 ± 9.4	<0.01
Females	21 (46.7)	22 (22.4)	<0.01
Diabetes	14 (31.1)	24 (24.7)	0.43
Hypertension	35 (77.8)	45 (46.4)	<0.01
Hypercholesterolemia	25 (61.0)	44 (45.8)	0.11
Current smokers	2 (4.7)	36 (39.6)	<0.01
Previously smoked	21 (48.8)	25 (27.5)	<0.01
Family history of CAD	9 (22.0)	20 (21.3)	0.93
Previous MI	14 (31.1)	15 (15.5)	0.03
Peripheral vascular disease	6 (13.3)	10 (10.4)	0.61
Congestive cardiac failure	6 (13.3)	6 (6.3)	0.16
Cerebrovascular disease	8 (17.8)	7 (7.2)	0.06
Previous PCI	5 (11.1)	12 (12.2)	0.85
Previous CABG	3 (6.7)	5 (5.1)	0.71
Renal failure*	11 (24.4)	11 (11.3)	<0.05
Clinical presentation			0.26
Non-STEMI	11 (24.4)	21 (21.4)	
STEMI	34 (75.6)	77 (78.6)	
Time period from symptom onset to PCI			0.91
< 6 h	24 (54.5)	55 (56.7)	
6–24 h	10 (22.7)	23 (23.7)	
25 h–7 days	10 (22.7)	19 (19.6)	
Median symptom-to-balloon time,† min (IQR)	228 (185–333)	206 (160–362)	0.62
Median door-to-balloon time,† min (IQR)	93 (70–148)	97 (65–126)	0.52

Data are n (%) or mean ± SD unless otherwise stated. *Renal failure defined as baseline creatinine >0.20 mmol/l. †For STEMI patients only.

CABG = coronary artery bypass graft; CAD = coronary artery disease; CS = cardiogenic shock; IQR = interquartile range (25th–75th percentile); MI = myocardial infarction; PCI = percutaneous coronary interventions; STEMI = ST-segment elevation myocardial infarction.

In-hospital mortality was 42.2% in the elderly group compared with 33.7% in the younger group (p = 0.32) (Table 3). Renal failure was a frequent complication among the elderly patients (28.9% vs. 12.2%, p = 0.02). Congestive cardiac failure occurred in 40% of elderly patients versus 25.5% in the younger group (p = 0.08). Periprocedural MI, emergency PCI, unplanned coronary artery bypass graft, bleeding, and stroke complications were not significantly different between the 2 groups.

The 30-day mortality was 43.2% in the elderly group compared with 36.1% in the younger group (p = 0.42). The 1-year mortality was 52.6% in the elderly group compared with 46.8% in the younger group (p = 0.56). There were no significant differences in 30-day or 1-year MACE, MI, target lesion revascularization, and TVR rates. Kaplan-

Table 2. Lesion Characteristics, Procedural Details, and Interventional Strategies

	Age ≥75 Yrs	Age <75 Yrs	p Value
Lesions, n	53	116	
Mean number of lesions per patient, n ± SD	1.18 ± 0.49	1.18 ± 0.42	0.94
Target vessel, %			
Left main	7.5	5.2	0.54
Left anterior descending	37.7	38.8	0.90
Bypass graft	0	1.7	1.00
Multivessel disease, %	93.1	68.3	<0.01
ACC/AHA B2 and C lesions, %	73.6	65.5	0.30
In-stent restenosis lesions, %	1.9	1.7	1.00
Ostial lesions, %	5.7	4.3	0.71
Bifurcation lesions, %	11.3	6.9	0.33
Small vessels ≤2.5 mm, %	24.5	17.2	0.27
Balloon angioplasty alone, %	13.3	5.2	0.09
Stent use, %	86.7	94.8	0.09
Drug-eluting stent use, %	28.9	29.6	0.93
Mean number of stents per patient, n ± SD	1.13 ± 0.73	1.11 ± 0.49	0.84
Mean total stent length, mm	22.72 ± 11.02	20.20 ± 9.95	0.17
Mean stent diameter, mm	3.03 ± 0.49	3.11 ± 0.50	0.33
Glycoprotein IIb/IIIa inhibitor use, %	68.9	65.3	0.67
IABP use, %	57.8	58.2	0.97
TIMI flow grade before procedure, %			0.90
0	56.9	56.9	
1	3.9	3.4	
2	15.7	12.1	
3	23.5	27.6	
TIMI flow grade after procedure, %			0.20
0	3.8	5.2	
1	3.8	0	
TIMI flow grade 2 or 3 after procedure, %	92.3	94.9	0.20

ACC/AHA = American College of Cardiology/American Heart Association; IABP = intra-aortic balloon pump; TIMI = Thrombolysis In Myocardial Infarction.

Meier curves of 1-year survival and freedom from MACE between the 2 groups are shown in Figures 1 and 2.

Predictors of outcome. Univariate predictors of in-hospital mortality with $p < 0.10$ were the presence of diabetes ($p = 0.05$), hypertension ($p = 0.02$), renal failure ($p < 0.01$), STEMI ($p = 0.03$), and intra-aortic balloon pump use ($p = 0.04$). Age ≥75 years was not a predictor ($p = 0.33$). Renal failure was the only significant multivariate predictor of in-hospital mortality with an odds ratio of 3.41 (95% confidence interval: 1.21 to 9.63; $p = 0.02$), as shown in Table 4.

Discussion

In this study of cardiogenic shock in the setting of MI, elderly patients selected for revascularization had a higher risk profile, including being female and having renal impairment, previous MI, and multivessel coronary artery disease. In spite of this, survival rates of the elderly in-hospital and at 1-year were not significantly different from the survival rates of a younger group. In addition, rates of MI, target-lesion revascularization, TVR, and MACE were similar between the 2 age groups.

In the SHOCK trial (17), patients with STEMI complicated by CS were randomly assigned to emergency revascularization or initial medical stabilization. The study reported a lower 6-month mortality rate with revascularization than in the medical therapy group (50.3% vs. 63.1%, $p = 0.027$). However, subgroup analyses showed that this benefit did not extend to patients ≥75 years old who experienced a 75% 30-day mortality with revascularization compared with 53.1% with medical therapy ($p = 0.16$). Importantly, the patient numbers were small (only 12 patients ≥75 years of age underwent early PCI and another 12 had coronary artery bypass graft surgery) (17,22).

Several larger observational studies have shown benefits of early revascularization in the elderly with CS (23–32). Within the large SHOCK registry (1993 to 1997) (23), which included 277 elderly patients, the in-hospital mortality of patients ≥75 years old was 48% with early revascularization (within 18 h of MI) compared with 81% in the late or no revascularization group ($p = 0.0002$). Among patients who underwent PCI, there was no difference in

Table 3. Clinical Outcomes: In-Hospital, 30 Days, and 1 Year

	Age ≥75 Yrs	Age <75 Yrs	p Value
In-hospital (n = 143)			
Mortality	19 (42.2)	33 (33.7)	0.33
Complications			
Periprocedural MI	2 (4.7)	2 (2.1)	0.41
Emergency PCI	1 (2.3)	1 (1.0)	0.53
Unplanned CABG	1 (2.3)	4 (4.3)	1.00
Bleeding	4 (8.9)	3 (3.1)	0.21
Congestive heart failure	18 (40.0)	25 (25.5)	0.08
Renal failure	13 (28.9)	12 (12.2)	0.02
Stroke	1 (2.2)	2 (2.0)	1.00
30 days (n = 141)			
Mortality	19 (43.2)	35 (36.1)	0.42
MI	2 (4.5)	3 (3.1)	0.65
TVR	2 (4.5)	6 (6.2)	0.70
MACE	22 (50.0)	40 (41.2)	0.33
1 year (n = 117)			
Mortality	20 (52.6)	37 (46.8)	0.56
Cardiac	17 (85.0)	34 (91.9)	0.65
Noncardiac	3 (15.0)	3 (8.1)	0.65
MI	2 (5.3)	3 (3.8)	0.66
TLR	3 (7.9)	5 (6.3)	0.71
TVR	3 (7.9)	6 (7.6)	0.96
MACE	24 (63.2)	42 (53.2)	0.31

Data are n (%) unless otherwise stated.

TLR = target lesion revascularisation; TVR = target vessel revascularisation; MACE = major adverse cardiac events; other abbreviations as in Table 1.

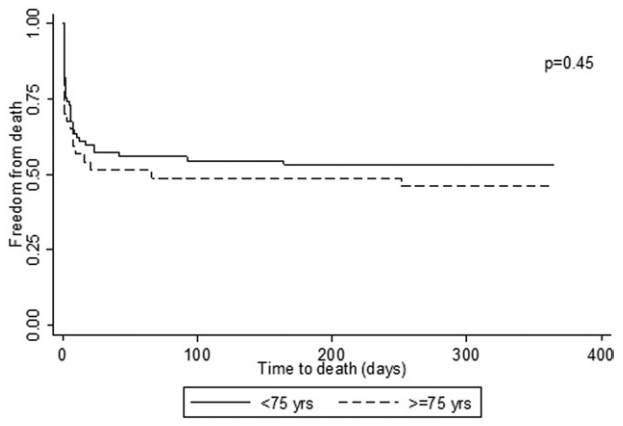

Figure 1. Kaplan-Meier Estimates of Cumulative 1-Year Survival

Kaplan-Meier estimates of cumulative 1-year survival in patients age ≥75 years versus <75 years.

in-hospital mortality between age groups (49% ≥75 years and 47% <75 years) but only a small percentage of elderly patients underwent PCI (15.9%, n = 39). A secondary analysis was performed in that study by excluding patients who died within 3 h of presentation, yielding an in-hospital mortality rate of 48% among elderly patients receiving early revascularization compared with 79% without early revascularization (23). Similarly, a study of CS by the Mayo Clinic between 1991 and 2000 evaluated patients ≥75 years old (n = 61) undergoing urgent PCI and the in-hospital mortality rate was 44% with a 30-day mortality of 47% (27).

Conversely, the ALKK (Arbeitsgemeinschaft Leitende Kardiologische Krankenhausärzte) European PCI registry

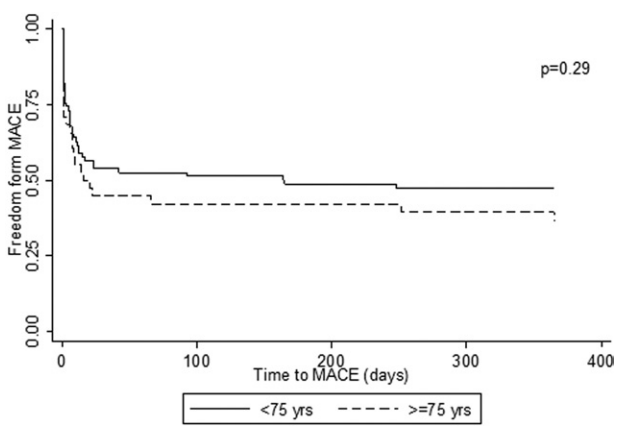

Figure 2. Kaplan-Meier Estimates of Cumulative 1-Year Freedom From MACE

Kaplan-Meier estimates of cumulative 1-year freedom from MACE, including death, myocardial infarction, and target vessel revascularization, in patients age ≥75 years versus <75 years.

Table 4. Multivariate Analysis of In-Hospital Mortality

Variable	Odds Ratio	95% CI	p Value
Renal failure	3.41	1.21–9.63	0.02
IABP use	2.11	0.97–4.59	0.06
STEMI	0.55	0.22–1.38	0.20
Diabetes	1.63	0.70–3.76	0.26
Hypertension	1.59	0.69–3.63	0.27
Age ≥75 yrs	1.04	0.46–2.36	0.93

CI = confidence interval; other abbreviations as in Tables 1 and 2.

(26) of 1,333 patients with CS found older age was an independent predictor of death and in-hospital mortality in patients >75 years was 63%. An analysis of the ACC-NCDR (American College of Cardiology–National Cardiovascular Data Registry) database of 483 patients undergoing PCI for CS from 1998 to 2002, found age along with female sex, renal insufficiency, total left anterior descending artery occlusion, no stent deployment, and no glycoprotein IIb/IIIa inhibitor use to be independent mortality predictors (6). A summary of these studies and outcome after PCI is presented in Table 5.

Why was the survival of elderly patients in our contemporary PCI study more favorable than in previous reports (17,23–34)? One possible explanation is the high rate of early reperfusion, with a median symptom-to-balloon time for elderly CS STEMI patients of 228 min. Greater than 50% of patients (in both age groups) had a symptom-to-PCI time of less than 6 h. Previous studies have shown that reperfusion time is especially important for survival in patients with CS compared with those without CS (25,35). Time from symptom onset to PCI was longer in both the SHOCK trial and ALKK registry. Another reason is likely related to the high rate of stent deployment (86.7% vs. 34% in the SHOCK trial) (17,22) and glycoprotein IIb/IIIa inhibitor use (36,37) (68.9% vs. 32% in the SHOCK trial) (22) in our ≥75 year olds when compared with the previous studies. Notably, in the elderly patients, stents were predominantly deployed in the culprit vessel only, despite a high incidence of multivessel disease. These temporal and procedural factors may also account for the fact that 92.3% of our elderly patients had TIMI flow grades 2 or 3 at the completion of the procedure compared with 81.8% in the SHOCK registry (23) and only 58% in the randomized SHOCK trial (22).

Study limitations. This study was a nonrandomized, observational study and multivariate analyses may not have fully accounted for the unmatched differences in baseline characteristics between the 2 groups. The number of elderly patients who underwent PCI were limited, an issue common to all studies of CS (Table 5). A larger sample size would improve the likelihood of determining whether significant differences in outcome between elderly and younger patients exist. The favorable outcomes after PCI in

Table 5. Studies on Cardiogenic Shock and Mortality After Early PCI

Study (Ref #)	Year Performed	n (Patients ≥75 Yrs Undergoing PCI)	Study Design	Mortality (%)			
				In-Hospital	30 Days	6 Months	1 Year
Current MIG study	2004–2007	45	Multicenter PCI registry	42	43		53
Migliorini et al. (24)	1995–2004	104	Single-center PCI registry		49	56	
Klein et al. (6)	1998–2002	143*	Multicenter PCI registry	64			
Antoniucci et al. (25)	1995–2001	71	Single-center PCI registry			51	
Zeymer et al. (26)	1994–2001	—†	Multicenter PCI registry	63			
Prasad et al. (27)	1991–2000	61	Single-center PCI registry	44	47		25‡
Dauerman et al. (28)	1990–2000	74	Multicenter PCI registry	46			
Dzavik et al. (23)	1993–1997	39	Multicenter SHOCK registry	49			
Hochman et al. (17), Webb et al. (22)	1993–1998	12 PCI, 12 CABG	Multicenter randomized SHOCK trial		75§	79§	83‖

*Patients were 70 to 79 years of age. †Number not quoted in study. ‡Of hospital survivors. §Of the PCI and CABG groups. ‖Of the PCI group only.
MIG = Melbourne Interventional Group; SHOCK = Should We Emergently Revascularize Occluded Coronaries in Cardiogenic Shock?; other abbreviations as in Table 1.

the elderly group may have been influenced by physician selection bias for patients deemed most likely to benefit from PCI, and exclusion of those patients in whom invasive treatment was deemed clinically futile.

Conclusions

In this study, 1-year survival of elderly patients with acute MI complicated by CS undergoing PCI using contemporary techniques was comparable with survival rates of younger patients. These data suggest that elderly patients presenting with CS may benefit from selective use of early revascularization and merits further investigation.

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Key Words: cardiogenic shock ■ elderly ■ acute myocardial infarction ■ percutaneous coronary intervention.

APPENDIX

For a list of the Melbourne Interventional Group Investigators, please see the online version of this article.