Original Article

Trends in Mortality from Acute Myocardial Infarction in the Coronary Care Unit†

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Abstract

Introduction: The treatment and outcome of acute myocardial infarction (AMI) has evolved greatly over the past few decades. We compared the mortality and complication rates of patients with AMI admitted to the Coronary Care Unit (CCU) in 2002 to previously reported data. Materials and Methods: All data for AMI patients admitted to National Heart Centre CCU in 2002 were collected through the Singapore Cardiac Data Bank, including demographics, in-hospital complications and mortality. These were compared to previous reports from the same institution in 1988, 1975 and 1967. Results: A total of 516 cases with AMI were identified. A higher proportion of patients were aged ≥70 years in 2002 (31.8%) compared to 1988 (25%), 1975 (11%) and 1967 (5.6%). Acute percutaneous transluminal coronary angioplasty (PTCA) was performed in 250 of 516 (48%) patients in 2002. The overall in-patient and age-standardised mortality was 14.7% and 10% respectively, compared to 20.6% and 17% respectively in 1988 (P = 0.06). For the 250 patients who underwent acute PTCA, overall mortality was 5.2% compared to 24% in those who did not (P <0.001). Common in-hospital complications included heart failure (38%), non-sustained ventricular tachycardia (8%), atrial fibrillation (8%) and complete heart block (6%). Age, heart failure, bundle branch block and sustained ventricular tachycardia were associated with higher mortality by univariate analysis. On multivariate analysis, older age, heart failure and the absence of percutaneous intervention were independently associated with higher mortality. Conclusion: In-hospital mortality for AMI patients admitted to the CCU declined from 1988 to 2002 despite a higher proportion of elderly patients. The introduction of new therapies including drugs and percutaneous intervention may have contributed to this decline.

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Introduction

Acute myocardial infarction (AMI) is a serious manifestation of coronary artery disease that is associated with high mortality from arrhythmias and heart failure. Its treatment has evolved over the decades. In the 1960s, coronary care units (CCUs) were developed to allow for close monitoring of AMI patients recognised to be at a higher risk of complications and death. Beginning in the late 1980s, and continuing in the 1990s, thrombolytic therapy was used for the treatment of AMI, and was shown to improve survival outcomes.[1-3] During this period, aspirin, beta-blockers and angiotensin-converting enzyme inhibitors were also shown to reduce mortality and morbidity.[2,4-6] In the 1990s, primary percutaneous transluminal coronary angioplasty (PTCA) for AMI was shown to be an effective alternative means of reperfusion, and is now increasingly practised in centres where experience is available.[7] In our institution, primary PTCA was introduced in the early 1990s and is now the preferred method of reperfusion. Over the decades, several studies have reported a decline in early mortality after AMI.[8-14]

There have been 3 previous studies describing the in-hospital mortality of AMI patients admitted to our institution's CCU,[15-17] in 1967, 1975 and 1988. The aim of this study was to examine trends in AMI demographics, mortality and morbidity over the past decades by comparing data from 2002 with previously published data from the same institution.

Materials and Methods

Patients

Data of all patients admitted to the National Heart Centre

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CCU in 2002 with AMI were collected through the Singapore Cardiac Data Bank. Patients were admitted either directly from the Emergency Department or transferred from other departments in the hospital. The diagnosis of AMI followed the WHO MONICA criteria for definite AMI, based on a combination of history, raised cardiac enzymes and electrocardiography.[19-21] Patients were categorised at the time of admission according to the classification of Killip and Kimball for signs of heart failure.[22]

These data were compared against an earlier cohort of 184 patients admitted over a 4-month period to our CCU in 1988,[15] and mortality data from previous studies in 1967 and 1975.[16,17] There was no age limit to admissions to CCU in 1988 and 2002, and AMI patients were admitted if they had acute ST-elevation myocardial infarction or if they were haemodynamically unstable requiring inotropic support or intra-aortic balloon pump counterpulsation. Patients who needed ventilatory support or monitoring for frequent ventricular arrhythmias were also admitted. We do not have data on admission policies for 1967 and 1975.

Statistical Analysis

Univariate analysis using chi-square tests assuming $P < 0.05$ as significant was performed to identify clinical features and complications associated with a poorer prognosis. Multiple logistic regression analysis was then carried out (using categorical modelling) to determine which factors were independently associated with a poorer prognosis.

Results

Demographics

In 2002, 516 patients were admitted to the CCU with AMI, of which 84% were ≥50 years of age (Table 1). Between the different periods, there was an increasing proportion of patients aged ≥70 years old: 5.6%, 11%, 25% and 31.8%, in 1967, 1975, 1988 and 2002 respectively ($P < 0.001$). There was also a declining proportion of patients below the age of 50 years, from 33% (1967) to 28% (1975), to 21% (1988) and 16.3% (2002). In 2002, 364 were men and 152 women, giving a male-to-female ratio of 2.4:1, compared to 2.7:1 in 1988.

Indians comprised a higher proportion of the study population (13%) compared to their proportion in the general population (8.1%, $P < 0.001$).[23-25] This was also noted in 1988 [17% of the study population compared to 7% in the general population, ($P < 0.001$)] (Table 2). From 1988 to 2002, the proportion of Indian and Malay infarct patients decreased, from 17% to 13% for Indians, and 18% to 13% for Malays. Correspondingly, there was an increase in proportion of Chinese patients in the study population in 2002, 71% compared to 60% in 1988 ($P < 0.001$).

Of the 516 patients with AMI admitted to CCU, 67% had ST-elevation myocardial infarction and 33% non-ST-elevation myocardial infarction. Forty-nine per cent had infarcts involving the anterior territory (including anterior septal and anterior lateral), 37% involving the inferior and 2.9% had both anterior and inferior territory infarcts. In 1988, 82% of all infarcts were Q-wave infarcts and 18% were non-Q-wave infarcts.

In 2002, primary PTCA was performed in 250 patients, 6 had thrombolysis and the others medical therapy. The reasons for conservative medical therapy included non-ST-elevation myocardial infarction, late presentation, lack of consent, or presence of contraindications. Primary PTCA was not available in 1988, and treatment options available then were either thrombolysis or medical therapy. Primary PTCA first became routinely practised in our institution in the early 1990s.

Complications of AMI

Table 3 shows the incidence of complications in 1988 and 2002. The patients in 2002 were further subdivided into those that had primary PTCA and those who did not. Heart failure, defined as Killip classification II and above, was the most common complication, affecting 39.7% in 1988 and 37.8% in 2002 (18.2% Killip II, 10.1% Killip III and 9.5% Killip IV). Of the patients who had PTCA, 24% had heart failure compared to 50.4% in those who did not undergo PTCA ($P < 0.001$). The incidence of heart failure also increased with the patient's age (Fig. 1). Below the age of 40 years, only 17% had heart failure compared to 54% above 69 years of age. Diabetes mellitus was also associated with higher rates of heart failure ($P = 0.008$).

Mortality of AMI

In-hospital mortality rates, including the age-specific and age-standardised rates for the different time periods,

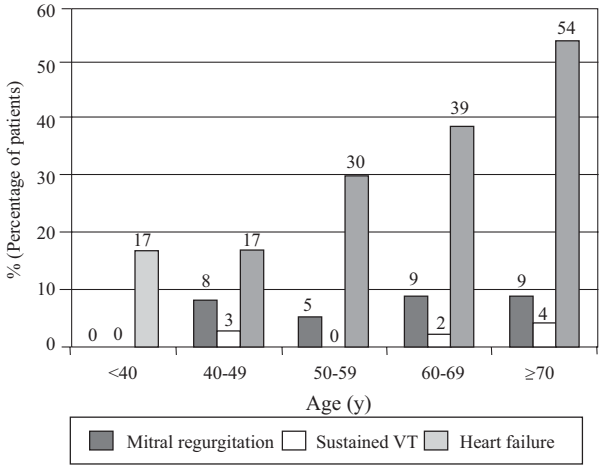

Fig. 1. Incidence of complications with age.

Table 1. Comparison of Age Distribution

	1967		1975		1988		2002	
Age	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
<50	112	33.2	111	27.8	38	20.5	84	16.3
50-59	118	34.9	135	33.8	44	23.8	123	23.8
60-69	89	26	108	27	56	30	145	28.1
≥70	19	5.6	45	11	46	25	164	31.8
Total	338	100	399	100	184	100	516	100

Table 2. Racial Distribution of Infarct Patients

Year	**1988**		**2002**		**2002 Singapore population**
Race	**n**	**%**	**n**	**%**	**%**
Chinese	111	60	365	71	76.5
Malay	33	18	67	13	13.8
Indian	32	17	65	13	8.1
Other	8	4.4	19	3.7	1.6
Total	184	100	516	100	100

are shown in Table 4. The overall in-hospital mortality for AMI patients admitted to CCU in year 2002 was 14.7% (76 of 516 cases), compared to 20.6% (38 of 184 cases) in 1988, and 16.5%, and 19.5% in 1975 and 1967 respectively. Most of the in-patient mortality occurred within 10 days of hospitalisation, 97.3% in 1988, and 79% in 2002. Increased age, the presence of heart failure, sustained ventricular tachycardia or bundle branch block were all significantly associated with an increased mortality using chi-square test (Table 5). Patients who did not undergo primary PTCA also had significantly higher mortality (P <0.001) compared to those who underwent PTCA. There was no difference in mortality between ST-elevation myocardial infarction versus non-ST-elevation myocardial infarction, as well as between anterior infarcts versus other locations.

Following multiple logistic regression analysis, the presence of any complications, age, heart failure and the absence of primary PTCA were all significantly associated with a worse prognosis. Table 4 compares the age distribution and mortality rates (crude and age-standardised) of our study in 2002 to those of previous studies (1967, 1975 and 1988). Mortality rates were higher in the more elderly age groups in all years except 1975. For patients ≥70 years of age, in-hospital mortality was 57.9%, 17.8%, 39.1% and 28% in 1967, 1975, 1988 and 2002 respectively. The age-standardised mortality rate declined from 22% in 1967 to 16.5% in 1975 and from 1975 to 1988 there was no change, 16.5% versus 17%. From 1988 to 2002, the mortality rate fell from 17% to 10% (P = 0.06).

Table 3. Complications of Infarct Patients

Complications	**1988**		**2002**		**2002**	
			Overall		**PTCA***	**No PTCA†**
	n	**%**	**n**	**%**	**%**	**%**
Cardiac failure	73	**39.7**	195	**37.8**	**24.4**	**50.4**
Mitral regurgitation	12	**6.5**	40	**7.8**	**6.4**	**9.0**
Non-sustained VT	21	**11.4**	42	**8.1**	**9.2**	**7.1**
Sustained VT	17	**9.2**	12	**2.3**	**0.8**	**3.8**
Ventricular fibrillation	12	**6.5**	26	**5**	**6.4**	**3.8**
Atrial fibrillation	12	**6.5**	41	**7.9**	**4.4**	**11.3**
Mobitz Type 1 HB	7	**3.8**	3	**0.6**	**1.2**	**0**
Mobitz Type 2 HB	3	**1.6**	1	**0.2**	**0**	**0.4**
Complete HB	12	**6.5**	30	**5.8**	**6.4**	**5.3**
No complications	91	**49.5**	300	**58.1**	**69**	**48.1**

HB: heart block; VT: ventricular tachycardia

* Percutaneous transluminal coronary angioplasty performed

† No percutaneous transluminal coronary angioplasty performed

Table 4. Comparison of Mortality by Age-specific Distribution

	1967	1975	1988	2002		
				Overall	PTCA*	No PTCA†
Age (y)	%	%	%	%	%	%
<50	12.5	11.7	10.5	4.2	0	14.3
50-59	16.1	14.8	15.9	6.5	5.3	8.3
60-69	24.7	23.2	16.1	12.4	5.6	18.9
>=70	57.9	17.8	39.1	28	10.4	35.3
Overall	19.5	16.5	20.6	14.7	5.2	23.7
Age-standardised to 1975 age distribution	22	16.5	17	10	NA	NA

* Percutaneous transluminal coronary angioplasty (PTCA) performed
† No percutaneous transluminal coronary angioplasty performed

Discussion

Our study documents an apparent decline in the overall inpatient mortality of AMI patients admitted to the CCU over the years from 1967 to 2002. The age-standardised mortality (Table 4) shows that this decline has occurred despite an increasing proportion of elderly infarct patients, who generally have more complications and poorer survival. In general, age-specific mortality rates also appear to have progressively improved in all age groups over the years.

Our findings are similar to those reported in the literature describing a fall in in-hospital mortality over the years.[8-14] Several registry studies have shown decline in short-term mortality between the early and late 1980s, as well as the 1990s.[26-29] Dauerman et al[26] showed a decline in Q-wave myocardial infarction mortality over a period of 10 years (1986-1988 to 1995-1997) of 19% to 14%.[26]

The changing age profile of AMI patients admitted to CCU has been previously described.[15-17,26] There has been an increase in the number of elderly patients while the proportion of patients aged <50 years old have shown a decreasing trend over the 4 periods (Table 1). The increasing trend in the proportion of elderly infarct patients is likely to be due to an ageing population, as well as possible differences in the patterns of patients seeking and obtaining medical treatment and hospitalisation over the years. It is essential that the current management of AMI take into consideration the growing proportion of elderly patients who account for most of the mortality and morbidity.[30-33]

In our study, age was shown to be a powerful predictor of mortality and heart failure, as previously reported elsewhere.[34-36] However, there appears to have been improvement in the mortality of elderly infarct patients over the years. In addition, when primary PTCA was performed, the mortality rate in 2002 for this group was only 10.4% (Table 4). Other independent prognostic factors of mortality include the presence of any complications, the presence of heart failure and the absence of PTCA (Table 5). The mortality rates of patients correlated closely to the degree of heart failure and Killip classification. In our population, class I heart failure had a mortality of 3.4%, class III, 35% and class IV, 82%. These results are comparable to the findings by Killip and Kimball.[22]

One exception to the general trend of improvement in age-specific mortality rates was the finding of a lower mortality for those over 70 years old in 1975. Although it is speculative, one possible explanation is variation in CCU admission policy, with stricter criteria for admission for elderly patients, perhaps excluding sicker and more elderly patients at that period. Indeed, the earlier study on CCU outcomes in 1967 found that elderly AMI patients have a poor prognosis, and on that basis, suggested that admission criteria to the CCU should be reviewed.

The higher proportion of Indian patients in our study population compared to the general population has been previously documented in other studies.[37] Mechanisms that have been suggested to account for a higher risk of AMI in Indians include a higher prevalence of diabetes and lower high-density lipoprotein cholesterol levels.[38] Of note, the proportion of Indians appears to have declined from 1988 (17%) to 2002 (13%).

The proportion of infarcts classified as non-ST-elevation myocardial infarction in 2002 was higher than the proportion of infarcts classified as non-Q-wave in 1988. Although non-ST-elevation myocardial infarction and non-Q-infarct are not directly equivalent, this comparison allows us to examine trends in the presentation of AMI. The higher proportion of non-ST-elevation myocardial infarction may be due to improved diagnostic capabilities due to the introduction of cardiac troponins, a more sensitive chemical marker of myocardial injury.[39-40]

Patients who underwent primary PTCA also had an overall lower incidence of complications, and a much

Table 5. Risk Factors for Mortality

Factor		Mortality (%)	*P* value
Age (y)	<50	4.8	
	50-59	6.5	
	60-69	12.4	<0.001
	≥70	28	
Gender	Male	13.7	0.325
	Female	17.1	
Race	Chinese	14.8	
	Malay	11.9	0.877
	Indian	16.9	
	Other	15.8	
Diabetes	Present	15.9	0.549
	Absent	14	
Hypertension	Present	14.8	0.967
	Absent	14.6	
Heart failure	Present	31.8	<0.001
	Absent	4.4	
Mitral regurgitation	Present	25	0.056
	Absent	13.9	
Bundle branch block	Present	32.1	0.008
	Absent	13.7	
Sustained VT	Present	100	<0.001
	Absent	12.7	
Complete heart block	Present	23.3	0.171
	Absent	14.2	
Type of infarct	STEMI	13.6	0.871
	NSTEMI	14.2	
Site of infarct	Anterior	13.1	0.759
	Others	14.2	
Complications	Present	29.2	<0.001
	Absent	4.3	
Primary PTCA	Performed	5.2	<0.001
	Not performed	23.7	

PTCA: percutaneous transluminal coronary angioplasty; VT: ventricular tachycardia

lower mortality. Almost half (48%) of the patients who underwent primary PTCA were 60 years of age and older, and about one-fifth (19%) were 70 years of age and older. This reflects the policy of our institution to treat AMI aggressively with percutaneous intervention whenever indicated, regardless of age. Although the lower mortality and complication rate for patients who underwent PTCA suggests a benefit from this treatment, this is an observational study, and there are confounding factors (e.g., earlier presentation, patient selection that may also explain this finding). Other factors, such as the beneficial effect of new therapeutic drugs introduced since the early 1980s and their more widespread use, such as the use of aspirin, heparin, beta-blockers and angiotensin converting enzyme-inhibitors, as well as the introduction of clopidogrel and low-molecular weight heparin in the late 1990s, may also have contributed to improved outcome over time.

Limitations

This is an observational study of AMI patients admitted to the CCU and does not allow us to establish a causal relationship between different medical variables, treatments and patient outcomes. There was no age limit to CCU admission in 1988 and 2002, and the admission criteria were generally similar. However, we do not have data on the admission policies in 1967 and 1975. In making comparisons between different time periods, it is difficult to exclude the effects of variation in the patterns of admission policies, as well as differences in the delay before admission following infarction between different periods. Other changes in population risk factors and general health cannot be controlled for. Better emergency response with faster arrival to hospital may have resulted in less severe presentation or fewer sick patients admitted to the CCU in 2002. These may have resulted in differences in the initial population at risk in the CCU and may confound any comparisons made between the different years. Our study in 2002 represents data collected over the period of 1 year; compared to a period of 4 months in 1988, and the data from 1976 and 1975 were collected over more than a year each. Despite these differences, there seems to be a consistent trend observed between the studies.

Conclusion

Our study reveals that the proportion of elderly AMI patients in the CCU has increased over the years. Despite this increasing age of AMI admissions to CCU, it is reassuring that the prognosis of AMI patients hospitalised in the CCU has improved. One major change in practice has been the use of primary PTCA, which was performed in 48% of patients admitted to our CCU in 2002, and appears to be associated with a better outcome. Despite these improvements, AMI continues to be a serious and potentially fatal condition, and further efforts are needed to reduce mortality.

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