Analysis of the Treatment of Acute Myocardial Infarction Using Ambulance Records in Japanese Cities

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By means of ambulance records, the current state of medical services for the treatment of acute myocardial infarction (AMI) was investigated in Chiba City and Ichihara City, Japan. From all patients transported by ambulance personnel in 1992 (n=31,191), 388 patients who were admitted within 2 weeks after the onset were studied. Types of admitting institution, diagnoses, medical treatments and prognoses were investigated. According to medical records, 168 patients fulfilled the criteria of definite AMI and were admitted alive. Percutaneous transluminal coronary angioplasty (PTCA) and recanalization (PTCR) were performed on 54 and 6 patients, respectively. The hospital case-fatality rates were lower in the patients who underwent emergency PTCA or PTCR than in the others. Emergency PTCA or PTCR, and admission to coronary care units (CCU) or institutions equipped with coronary angiography, decreased the fatality risk, even after considering age, sex, and disease severity. These results show the importance of the selection of institutions for AMI patients. Because 40% of definite AMI patients were sent to institutions without CCU, it is essential that enough CCU are available through an improvement in cooperation between the various types of institutions, and in the proper transfer of AMI patients to CCU (*Jpn Circ J* 1999; 63: 170–176)

Key Words: Acute myocardial infarction; Ambulance records; Case-fatality rates; MONICA criteria; Recanalization therapy

The usefulness of recanalization therapy that includes thrombolytic therapy and emergency percutaneous transluminal coronary angioplasty (PTCA) for acute myocardial infarction (AMI) is recognized¹ and this procedure is widely performed as a primary treatment. Decreases in the case-fatality rates from AMI from approximately 30% to 10% have been reported with this therapy. However, many more institutions that specialize in cardiology and offer these procedures are needed. Average rates of fatality within 28 days after AMI were 48% for males and 54% for females according to the multinational monitoring of trends and determinants in cardiovascular disease (MONICA) project (21 countries; age 35–64 years)². In spite of the usefulness of recanalization therapy, it has not been available for all eligible AMI patients worldwide. In the US, thrombolysis is considered the first line of therapy for AMI in suitable patients, but in a recent report it was used in only 70% of ideal candidates.³ In Japan, the mortality rate for AMI is low compared with that in the US or European countries, and there is a concentration of specialty institutions in urban districts at which patients can conveniently receive emergency PTCA or percutaneous transluminal coronary recanalization (PTCR) treatment.

Although many reports describe results of medical treatment at specific institutions, there have been few investigations to determine the actual treatment situation for patients in an entire area. In order to determine treatment strategies

for AMI, we studied the ambulance records from Chiba City and Ichihara City, Japan. We perused the medical records of the admitting institutions for all patients arriving by ambulance with a diagnosis of AMI, reconfirmed the diagnoses, and ascertained the medical treatment given in the acute phase. We also determined the availability of equipment and personnel for cardiac care in the admitting institutions and the case-fatality rates. Based on this information, recommendations are made.

Methods

Study Population

From all 1992 ambulance records (n=31,191) from the Fire Departments in Chiba City and Ichihara City, Chiba Prefecture, Japan, we determined that 401 patients were admitted to hospital for AMI. Thirteen patients were excluded because they were seen more than 2 weeks after the onset of symptoms. Of the remaining 388 patients admitted within 2 weeks after the onset of symptoms, we examined the medical records of the institutions to which the patients were finally admitted and treated, reconfirmed the diagnoses using MONICA criteria⁴ and determined what medical treatments were given. Briefly, the criteria for definite AMI were: (1) definite ECG changes; (2) probable ECG changes and abnormal enzymes; (3) typical symptoms and abnormal enzymes; or (4) fatal case with the appearance of fresh myocardial infarction and/or recent coronary occlusion found at necropsy. There were 171 patients who fulfilled the criteria, which included 168 patients admitted alive (Fig 1). Because observation periods were different among the institutions, we could evaluate outcome only by death occurring in the hospital. After hospital discharge, follow-up was impossible. As of

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Fig 1. Schematic representation of the selection process and sample attrition.

October 1992, Chiba City, the capital of Chiba Prefecture, had a population of 841,914 (7.4% ≥ 65 years of age) and an area of 272.4 km². Ichihara City is located to the south of Chiba City, and had a population of 267,004 (8.4% ≥ 65 years of age) and an area of 367.9 km². Combined, these cities had a population of 1,108,918 (7.6% ≥ 65 years of age) and an area of 640.3 km².

Classification of Admitting Institutions

According to the availability of equipment and personnel for cardiac care, the admitting institutions were classified into 5 groups: Type A, PTCA or PTCR always available; Type B, PTCA or PTCR available only at certain times; Type C, coronary angiography (CAG) available but not PTCA or PTCR; Type D, CAG, PTCA or PTCR not available; and Type E, outpatient clinic only. In Chiba City there were 1 Type A, 5 Type B, 1 Type C, 38 Type D, and 471 Type E institutions, and in Ichihara City there were 0 Type A, 1 Type B, 1 Type C, 11 Type D, and 112 Type E institutions. In these 2 cities, only Type A institutions were equipped with a coronary care unit (CCU).

Main Outcome Measure

We examined the availability of recanalization treatment and various time periods; that is, the time from onset of symptoms to the call to the Fire Department (decision time), the time from the call to the Fire Department to the arrival of ambulance personnel at the patient's side, the time from the call to the Fire Department to arrival at the primary or admitting institution, and time from onset of

symptoms to admission. In addition to age and sex, patient data such as infarct site, existence of hypotension, tachycardia on arrival, and previous myocardial infarction were used as measures of disease severity.

Statistical Analyses

The factors of sex, age, and hospital case-fatality rates were compared in relation to the type of treatment by Chi-square test. Comparisons between the discharged-alive group and the hospital-death group were also performed. The comparisons of age and the time periods between the discharged-alive group and the hospital-death group were done by Wilcoxon's test. Further, the factors associated with hospital death were evaluated by multiple logistic regression.

Results

Analysis of 388 Patients Admitted Within 2 Weeks of Onset

The types of institutions and the final diagnoses of 388 patients admitted within 2 weeks after onset of symptoms of AMI are shown in Table 1. Of these, 262 patients were admitted to Type A, B or C institutions, with 144 patients being admitted to Type A institutions. Among 13 patients admitted to Type E institutions, there were 8 patients with no AMI, 4 patients with cardiopulmonary arrest, and 1 patient for whom there was no information. There were 171 patients who fulfilled the MONICA criteria, which included 4 patients with cardiopulmonary arrest upon arrival, 1 of whom survived. Possible AMI totalled 49 cases, with cardiopulmonary arrest in 39 of these. Among the 149 cases with the diagnosis of no AMI, there were 4 cases of cardiopulmonary arrest. Fatal cases with insufficient data numbered 11. Lack of information was present in 8 cases (lost medical records, permission for perusal was not obtained, etc). The time from onset of symptoms to admission for 47% of cases was within 2 h, for 75% within 6 h, and for 18% more than 12 h. Finally, 67 patients (40% of the patients with definite AMI admitted alive) were sent to institutions without CCU, and 21 patients (13%) were sent to institutions not equipped to perform CAG.

Analysis of 168 Patients With Definite AMI Admitted Alive

The characteristics of 168 patients with definite AMI admitted alive who received 4 types of treatment are shown in Table 2. Fifty-two patients underwent emergency PTCA (including primary, rescue, and immediate PTCA), 6 patients had PTCR, 36 patients were given only intravenous thrombolysis and 74 patients were given conservative therapy. In the emergency PTCA and PTCR groups, the percentages of patients aged < 70 years or who were male were higher than in the other groups. In the intravenous thrombolysis group, only 11.1% underwent emergency CAG.

Comparison of the Discharged Alive and the Hospital Mortality Groups

A comparison of data between patients who were discharged alive ($n=136$) and those who died in the hospital ($n=32$) is shown in Table 3. The median age was lower and the percentage of males was higher in the discharged-alive group than in the hospital-death group. There were no significant differences in rates of anterior infarction,

Table 1 Final Diagnosis of the 388 Patients ≤ 2 Weeks After Onset of Acute Myocardial Infarction (AMI) and Type of Admitting Institution

	Admitting institution					Total (n=388)
	Type A (n=144)	Type B (n=77)	Type C (n=41)	Type D (n=113)	Type E (n=13)	
Definite AMI	103 (2)	27	19 (1*)	22 (1)	0	171 (4*)
Possible AMI	7 (6)	11 (10)	4 (2)	25 (19)	2 (2)	49 (39)
No AMI or coronary death	32 (2)	36	17	56 (2)	8	149 (4)
Fatal case with insufficient data	1 (1)	1 (1)	1 (1)	6 (6)	2 (2)	11 (11)
Lack of information	1	2	0	4	1	8

Diagnosis of definite and possible AMI, no AMI or coronary death, and fatal cases with insufficient data were based on WHO MONICA criteria. Classification of admitting institutions (Types A~E) is described in Methods. No. patients with cardiopulmonary arrest on arrival is indicated in parenthesis. *One case survived.

Table 2 Characteristics of the 168 Patients With Definite AMI Admitted Alive Who Received 1 of 4 Types of Treatments

	Emergency PTCA (n=52)	Emergency PTCR (n=6)	Intravenous thrombolysis (n=36)	Conservative therapy (n=74)
<i>Demographics</i>				
Age <70 (%)	80.8	83.3	52.8	56.8
Male sex (%)	90.4	83.3	66.7	66.2
<i>Clinical findings</i>				
Onset of symptoms to admission ≥ 6 h (%)	15.4	0.0	11.1	40.5
Anterior infarction (%)	59.6	66.7	63.9	51.4
<i>Hemodynamic findings on arrival</i>				
Systolic blood pressure <100 mmHg (%)	5.8	16.7	19.4	20.3
Pulse rate ≥ 100 beats/min (%)	15.4	33.3	16.7	27.0
<i>Examination</i>				
Emergency CAG attempted (%)	100.0	100.0	11.1	2.7
Confirmation of recanalization by emergency CAG (%)	90.4	83.3	75.0*	0.0*
Moderate or severe lung congestion (%)	5.8	0.0	22.2	27.0
Admitted to CCU (%)	96.2	50.0	22.2	37.8
Hospital case fatality rates (%)	0.0	16.7	25.0	29.0

*The ratio of confirmation of recanalization to emergency CAG attempted.

Table 3 Characteristics of the 168 Patients With Definite AMI Who Were Admitted Alive According to Outcome

	Discharged alive group (n=136)	Hospital death group (n=32)	p value
<i>Demographics</i>			
Age, median (range)	61 (35~88)	73 (53~92)	<0.001
Male sex (%)	81.6	40.6	<0.001
Anterior infarction (%)	54.4	71.9	0.094
<i>Hemodynamic findings on arrival</i>			
Systolic blood pressure <100 mmHg (%)	9.6	40.6	<0.001
Pulse rate ≥ 100 beats/min (%)	24.3	15.6	0.463
Previous myocardial infarction (%)	11.8	21.9	0.226
<i>Institutions and examination</i>			
Admitted to institutions not equipped with CAG (%)	7.4	37.5	<0.001
Admitted to CCU (%)	59.6	25.0	<0.001
Emergency CAG attempted (%)	45.6	3.1	<0.001
Confirmation of recanalization by emergency CAG (%)	40.4	3.1	<0.001
<i>Time required for transfer, min median (range)</i>			
Onset of symptoms to call to Fire Department	139 (3~14,980)	65 (7~8,640)	0.095
Call to Fire Department to ambulance personnel's arrival at patient's side	4 (1~12)	4 (2~10)	0.175
Call to Fire Department to arrival at first institution	22 (8~101)	21 (8~40)	0.511
Call to Fire Department to admission	26.5 (8~386)	27 (11~106)	0.688
Onset of symptoms to admission	190 (20~15,000)	112 (21~8,640)	0.033

percentage of patients with a pulse rate ≥ 100 beats/min on arrival, and previous myocardial infarction between the 2 groups. The percentages of patients with a systolic blood pressure less than 100 mmHg on arrival and of those admitted to institutions not equipped to perform CAG (Type D)

were significantly lower in the discharged-alive group than in the hospital-death group. The percentages of patients who were admitted to CCU, in whom emergency CAG was attempted, and in whom recanalization were confirmed were significantly higher in the discharged-alive group than

Table 4 Odds Ratios and 95% Confidence Intervals (95% CI) for Hospital Deaths by Multiple Logistic Regression Analysis in Patients with Definite AMI Admitted Alive (n=168)

	Odds ratio	95% CI	p value
Age (10 year increments)	1.48	0.89~2.47	0.129
Male sex	0.14	0.04~0.46	0.002
Anterior infarction	6.36	2.00~24.0	0.003
Systolic blood pressure <100mmHg on arrival	13.80	3.84~59.8	0.001
Pulse rate ≥100 beats/min on arrival	0.36	0.08~1.38	0.157
Previous myocardial infarction	2.19	0.47~9.83	0.305
Time from onset of symptoms to call to the fire departments (1 h increments)	0.98	0.97~1.01	0.127
Time from call to Fire Department to admission (1 h increments)	1.89	0.03~114	0.760
Type of treatment			
Conservative therapy	1.00		
Only intravenous thrombolysis	0.55	0.15~1.85	0.346
Emergency PTCA or PTCR	0.07	0.003~0.56	0.029

in the hospital-death group.

The median time from onset of symptoms to admission was 190 min in the discharged-alive group and 112 min in the hospital-death group, with the difference being statistically significant. For other median time components, there were no significant differences between the 2 groups (Table 3).

Multiple Logistic Regression Analysis for Hospital Deaths of Definite AMI Patients

The results of multiple logistic regression analysis of the factors that affected hospital deaths among the 168 patients with definite AMI admitted alive are shown in Table 4. As the age of patients increased in 10-year increments, the odds ratio for hospital death was 1.48. The odds ratio of males versus females was 0.14, which was significantly low. The odds ratios for deaths of patients with anterior infarction or systolic blood pressure less than 100 mmHg on arrival were significantly high. Undergoing emergency PTCA or PTCR significantly decreased the hospital death rate compared with conservative therapy only (odds ratio=0.07). Intravenous thrombolysis also decreased the rate (odds ratio=0.55), but its effect was not significant. There was no significant relationship between the incidence of hospital deaths and pulse rates on arrival, previous myocardial infarction, time from onset of symptoms to call to the Fire Department or interval from the call to the Fire Departments to admission.

If the type of treatment was not used for calculation, but rather admission to CCU or admission to institutions equipped with CAG, the odds ratio was 0.30 or 0.11, respectively, values that were significantly low. Influences from other factors were almost the same as those from our previous results (data not shown).

Discussion

In order to decrease the mortality rates of AMI, the effects of improvement in supervision and treatment have been studied. Reports have described the shortening of decision time by means of early recognition of symptoms by education of patients,⁵ the 'chain of survival' concept advocated by the American Heart Association,⁶ thrombolytic therapy,⁷⁻¹³ anticoagulant therapy,^{7,8,14,15} emergency PTCA,^{13,16-23} assisted circulation^{24,25} and a system to determine the effect of prehospital-initiated treatment of myocardial infarction.^{26,27}

Many reports have shown that case-fatality rates of AMI

patients arriving quickly at specialty institutions are decreased by recanalization therapy and assisted circulation in contrast to patients not so treated. However, even in a report of the Tokyo CCU network, considered as an ideal model of the Japanese AMI emergency medical system, only one quarter of AMI patients were admitted to a CCU.²⁸ In order to improve survival rates in an entire area, it is necessary to increase the number of patients who can be accommodated by specialty institutions. To implement such reform, it is imperative in each particular area to fully understand the treatment situation of all patients who experience AMI. Previously, death certificates have often been examined to estimate the incidence of sudden cardiac death due to AMI, and to reevaluate all heart disease deaths.^{29,30} In these studies, however, an evaluation of survivors was not conducted.

The present study is an analysis of all patients who used fire department ambulances in Chiba City and Ichihara City. It is acknowledged that there are patients who did not use these ambulances, patients whose cause of death was listed as cardiopulmonary arrest and 'acute heart failure', whose illnesses were not listed as AMI but later diagnosed as AMI, and whose AMI diagnosis occurred during admission. Therefore, this study may not have included all AMI patients, but AMI has a high degree of severity and the frequency that such patients request ambulances is high. Also, there are few private ambulances in Japan. The incidence of definite AMI (n=171, male and female) that we found was 15 per 100,000 (total population, not age standardized) and that of AMI that included possible cases (n=220) was 20 per 100,000. This indicates that most AMI patients within these 2 cities may have been included in this investigation, as age standardized annual rates for men with AMI in the MONICA project in Japan were 25 per 100,000 (population aged 25-75 years).³¹ We diagnosed AMI by means of not only progression of Minnesota codes on serial ECGs, cardiac enzyme levels twice the normal limit, and findings at necropsy according to MONICA diagnostic criteria, but also by results of echocardiograms and CAG.

As an index of specialty institutions of cardiology, the medical treatment systems for recanalization therapy, the equipment for CCU, and the existence of a full-time specialist of cardiology can be used. In the present study, the institutions were classified mainly by means of medical treatment systems for recanalization therapy. In both cities, there was only one with a CCU. We adopted type C institutions as a classification item in addition to the medical

treatment system, with the rationale that the equipment for CAG probably means the existence of a full-time specialist. In the future, we will be able to use 'a fellow of Japanese Circulation Society' as an index.

The usefulness of emergency PTCA and PTCR has been shown in numerous studies.^{17,32,33} In the present study, the odds ratio of hospital death was significantly lower for the patients who underwent emergency PTCA or PTCR in comparison with the other groups, even though we considered age, sex and disease severity by multiple logistic regression. Also, among AMI patients who were considered eligible for recanalization therapy, the case-fatality rates of those who underwent emergency PTCA or PTCR were lower in comparison with those who underwent only intravenous thrombolysis or conservative therapy. As well, 89% of the patients with intravenous thrombolysis did not undergo emergency CAG, and their infarcted arteries were not evaluated. Therefore, we distinguished intravenous thrombolysis only from emergency PTCA or PTCR. These findings from our retrospective study suggest the usefulness of emergency PTCA and PTCR, even though the advantages of a prospective randomized study are recognized. PTCA and PTCR as the primary treatment strategies are limited by the availability of institutions offering them and by the availability of personnel for cardiac catheterization and physicians qualified to perform angioplasty and recanalization. Because of this, intravenous thrombolysis has become established as the first line of therapy for AMI in suitable patients in the USA.

Chiba City and Ichihara City are neighboring towns of the Metropolis of Tokyo, and the population includes many office and factory workers, so we can consider them as typical Japanese cities. It was clear from a report of Keys et al that the incidence of coronary heart disease in Japan is low.³⁴ In the MONICA project, coronary rates for men in Germany, New Zealand, Australia, and Finland (1985–89) were 298–838 per 100,000, whereas the rates in Japan were 25 per 100,000.³⁵ From a report of the National Heart, Lung and Blood Institute of the National Institutes of Health in the US, mortality from coronary heart disease in Japan is the lowest in the world.³⁶ Japan is small and there are many institutions equipped with CAG, and because all citizens have health insurance, physicians can easily provide emergency PTCA or PTCR. Results from a questionnaire in 1994 from 170 institutions from all over Japan showed that over 50% of patients received primary PTCA.³⁷ However, these were mostly patients admitted to specialty institutions of cardiology. In a report from the US in 1990, of an estimated 675,000 patients admitted to hospitals with a diagnosis of AMI, less than 20% received fibrinolytic therapy, and 15% did not receive fibrinolytic therapy even though they were ideally suitable for thrombolysis.³⁸ This suggests that worldwide, in spite of the eligibility for recanalization therapy, there must be many who do not receive emergency PTCA, PTCR, or thrombolytic therapy because they were admitted to institutions without the personnel or equipment for their administration.

In the present study, 101 patients (61%) with definite AMI who were admitted alive were finally conveyed to a Type A institution. Unless there were contraindications, emergency PTCA or PTCR were done on the eligible patients irrespective of the time of onset, and there were no hospital deaths among the patients who underwent these procedures. The patients who were admitted to a CCU and those who were admitted to institutions equipped with

CAG had a significantly low risk of hospital death. From these findings, we conclude that it is important for AMI patients to be admitted to a CCU and undergo medical treatment by cardiovascular specialists in institutions with the capability to perform CAG, even though there may not be provision for recanalization therapy. Thus, this study showed the importance of the selection of institutions for AMI patients. In total, 40% of the patients with definite AMI admitted alive were sent to institutions without CCU. Enough CCU and the proper transfer of AMI patients to CCU are necessary in an emergency system. In particular, from a realistic point of view including costs and time periods, we should first improve the transfer system from primary institutions to appropriate specialty institutions of cardiology.

As only one Type A institution considered primary PTCA as the first treatment for AMI, the numbers of PTCR and intravenous thrombolysis-only therapies were smaller than that of emergency PTCA. Therefore, there may be a bias among the results of this study. Because many patients are transferred to this Type A institution from Type D and E institutions, an improvement in the accuracy of diagnosis in primary institutions is desirable in order to make the best use of the Type A institution. The rates of definite AMI in hospital discharge statistics were reported to be 58–64% in trials in which symptoms of suspected AMI were considered as diagnostic^{39,40} and 94% in a trial in which chest pain accompanied by ST segment elevation or depression of the ECG was considered as diagnostic.⁴¹

In the European Myocardial Infarction Project (EMIP), the benefits and risks of prehospital thrombolytic therapy were evaluated, and the accuracy of the prehospital diagnosis was high (88%).²⁷ Compared with the findings in the present study whereby AMI was diagnosed or suspected in the admitting institutions in the acute phase, the rate of definite AMI was 44.1% (56.7% if we include possible AMI) and, even if we restrict figures to those patients who were admitted alive, it was 50.8% (53.8% if we include possible AMI). With this relatively low rate of accuracy, it might be difficult to make good use of Type A institutions. We think that a program of consultations with specialists, including transmission of ECG data, is necessary to improve the diagnostic accuracy in primary institutions for patients in the acute phase of AMI.

Among 168 patients with definite AMI who were admitted alive, the time from onset of symptoms to admission was significantly longer in the discharged-alive group than in the hospital-death group. There is the possibility that the more severe the patient's condition (eg, shock), the sooner the Fire Department was called and the patient conveyed to the institutions.⁴² With multiple logistic regression of disease severity, there was no significance between the time of onset of symptoms to time of call to the Fire Department, time from the call to the Fire Department to admission and hospital death.

Conclusions

The hospital case-fatality rates of AMI patients who underwent emergency PTCA or PTCR were lower than those receiving other therapies. The admission to a CCU or institutions equipped with CAG also decreased the hospital case-fatality rate. Because 40% of the patients with definite AMI admitted alive were sent to institutions without CCU, it is essential that enough CCU are available through an

improvement in the cooperation between various types of institutions in order to raise the precision of the diagnosis in the acute phase, and to correctly transfer AMI patients to a CCU.

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