One-Year Clinical Outcome of Interventionalist- Versus Patient-Transfer Strategies for Primary Percutaneous Coronary Intervention in Patients With Acute ST-Segment Elevation Myocardial Infarction
Results From the REVERSE-STEMI Study

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Background—Traditional reperfusion options for patients with acute ST-segment elevation myocardial infarction (STEMI) presenting to non-primary percutaneous coronary intervention (PPCI)-capable hospitals generally include onsite fibrinolytics or emergency transfer for PPCI. A third option, involving interventionalist transfer, was examined in the REVERSE-STEMI study.

Methods and Results—A total of 334 patients with acute STEMI who presented to 5 referral hospitals with angiographic facilities but without interventionalists qualified for PPCI were randomized to receive PPCI with either an interventionalist- (n=165) or a patient-transfer (n=169) strategy. The primary end point of door-to-balloon (D2B) time and secondary end points of left ventricular ejection fraction and major adverse cardiac events (MACE) at 1-year clinical follow-up were compared between the 2 groups. Compared with the patient-transfer strategy, the interventionalist-transfer strategy resulted in a significantly shortened D2B time (median, 92 minutes versus 141 minutes; *P*<0.0001), with more patients having first balloon angioplasty within 90 minutes (21.2% versus 7.7%, *P*<0.001). This treatment strategy also was associated with higher left ventricular ejection fraction (0.60±0.07 versus 0.57±0.09, *P*<0.001) and improved 1-year MACE-free survival (84.8% versus 74.6%, *P*=0.019). Multivariate Cox proportional hazards modeling revealed that the interventionalist-transfer strategy was an independent factor for reduced risk of composite MACE (hazard ratio, 0.63; 95% CI, 0.45 to 0.88; *P*=0.003).

Conclusions—The interventionalist-transfer strategy for PPCI may be effective in improving the care of patients with STEMI presenting to a non-PPCI-capable hospital, particularly in a congested cosmopolitan region where patient transfers could be prolonged.

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Key Words: myocardial infarction ■ angioplasty ■ stents ■ outcome and process assessment

In patients with ST-segment elevation myocardial infarction (STEMI), rapid implementation of coronary reperfusion is extremely crucial for myocardial salvage and prognostic improvement[1]; thus, various reperfusion strategies have been suggested by current guidelines.[2] Primary percutaneous coronary intervention (PPCI), when performed in a qualified center in a timely manner, is associated with superior clinical outcomes, as opposed to fibrinolysis,[3] and has become the first treatment option for patients with STEMI presenting to a hospital with PPCI capability.[4] For patients presenting to a non-PPCI-capable hospital, although a pharmacoinvasive interhospital patient-transfer strategy was proposed, many patients with acute STEMI requiring transfer for PPCI still had treatment delay from symptom onset to pharmacological or mechanical intervention far exceeding the recommended 90 minutes.[4,5] Currently, almost half of hospitals equipped with

angiographic facilities lack interventionalists qualified for PPCI in China, where the volume of PCI has increased dramatically in recent years.[4] The strategy of transferring patients with STEMI in large cities is still not consummate.[4,6] In the RESVERSE-STEMI study, we sought to examine whether an interventionalist-transfer strategy for PPCI could further shorten door-to-balloon (D2B) time and improve 1-year clinical outcome in patients with acute STEMI.

WHAT IS KNOWN
- Primary percutaneous coronary intervention (PPCI) is the preferred treatment option for patients with ST-segment elevation myocardial infarction (STEMI) presenting to PPCI-capable hospitals.
- Interhospital transfer often is used for patients with STEMI who present to hospitals without PPCI capability.

WHAT THE STUDY ADDS
- This multicenter, prospective, randomized clinical study compares the 1-year outcomes of patients with STEMI treated by a strategy of interhospital patient transfer versus that of interventionalist transfer to regional hospital PPCI.
- The interventionalist-transfer strategy resulted in significantly shorter door-to-balloon times and better 1-year clinical outcomes.
- This novel strategy of interventionalist transfer for PPCI may improve the care of patients with STEMI presenting to a non-PPCI-capable hospital, particularly in regions where patient transfers are prolonged by delays in transport.

Methods

Study Design and Patient Population

A total of 351 consecutive patients with STEMI within 12 hours of symptom onset who presented to 5 referral hospitals with angiographic facilities but without interventionalists qualified for PPCI were enrolled between November 2005 and November 2007. Seventeen patients were excluded before randomization because of refusal of interventional treatment (n=13) or loss of consciousness on admission (n=4). The remaining 334 patients were randomized to receive PPCI using either an interventionalist- (interventionalist-transfer group, n=165) or a patient- (patient-transfer group, n=169) transfer strategy by a 24-hour computer-generated random-allocation system (Figure 1). One single tertiary hospital provided experienced interventionists to perform procedures in the referral hospitals or received referral patients and then performed PPCI in the tertiary-care hospital. The mean distance between referral and tertiary-care hospitals was 17.5 km (range, 10.7 to 25.4 km) (Figure 2). During the study period, 2 or more qualified interventionalists in the tertiary hospital were always on standby in case the local hospitals received patients with STEMI at the same time. For the interventionalist-transfer strategy, only 1 interventional cardiologist was sent from the tertiary hospital to the local hospital each time after receiving an emergency call, whereas nurses or paramedics adequately trained to provide care for patients with acute STEMI and their often acute problems and complete PCI materials were supplied by the local hospitals. For the patient-transfer strategy, ambulances with paramedic personnel qualified to perform cardiopulmonary resuscitation

were sent from a regional service center to the local hospitals and then transferred the patients to the tertiary hospital to receive PPCI.[7] All referral hospitals had a coronary care unit and diagnostic cardiac catheterization laboratory. The cardiac interventional team, including operator, nurses, and technicians, was qualified and approved in performing elective PCI (minimum annual volume, 75 cases). For the care of patients with STEMI, a formal training program was implemented for technicians and nurses in the referral hospitals before starting the study.[8] One of the 5 referral hospitals had cardiac surgery on site. The study protocol was approved by the hospital ethics committees of all participating centers, and written informed consent was obtained from all patients.

Medical Treatment and Coronary Intervention

All patients were treated with loading doses of aspirin (300 mg) and clopidogrel (300 mg) after a diagnosis of STEMI was made, but the use of platelet glycoprotein IIb/IIIa inhibitor (tirofiban) was at the discretion of physicians. PPCI, including balloon predilatation and stent implantation, was performed only for infarct-related artery (IRA) with thrombolysis in myocardial infarction (TIMI) flow grade ≤ 2. Intracoronary stents were implanted as a final treatment option when the anatomy was suitable. Procedural success was defined as residual stenosis $\leq 20\%$ after intervention; TIMI flow grade >2; and absence of death, emergency bypass surgery, and disabling cerebral events.[9] After the procedure, clopidogrel (75 mg/d) was continued for at least 12 months in all patients because of the setting of MI, irrespective of implantation of either bare-metal or drug-eluting stents. Aspirin (100 mg/d) was prescribed indefinitely in all patients.

End Points and Definitions

The primary end point was D2B time measured from the patient's arrival at the local hospital to first balloon inflation. The secondary end points included left ventricular ejection fraction and major adverse cardiac events (MACE), including death, recurrence of nonfatal MI, and target vessel revascularization at 1-year clinical follow-up. Death included cardiac and noncardiac death. Recurrence of nonfatal MI was defined as recurrent chest pain lasting ≥ 30 minutes after index procedure, associated with new Q waves or recurrent ST elevation ≥ 0.1 mV in at least 2 contiguous leads, and re-elevation of creatine kinase MB isoenzyme to at least twice the upper limit of normal and $>50\%$ above the previous value.[9] Target vessel revascularization was defined as repeat PCI or surgical bypass for any segment of the target vessel. The occurrence of stent thrombosis according to the Academic Research Consortium (ARC) criteria was also monitored at one-year follow-up.[10]

Follow-Up

Follow-up was completed by an interview of patients in the cardiac clinic or by telephone conversation with patients or their relatives every 3 months after discharge, and continued for ≥ 1 year. None of the hospital survivals were lost to follow-up. Relevant information regarding the patient's state of health and medications was obtained. The follow-up process was monitored by the tertiary hospital, and 25% of the follow-up data provided by the referral hospital were checked by the tertiary hospital. In patients with MACE, a detailed, predesigned questionnaire was completed by the relevant physician. Transthoracic 2D echocardiography was performed in the local or tertiary hospitals where PPCI was carried out. Left ventricular volumes and ejection fractions were determined with apical 4-chamber view using the modified Simpson method during hospitalization and at 6-month and 1-year follow-up.[11] All MACE were continuously reviewed by the critical events committee members, who were blinded to treatment options, and echocardiographic studies were sent to a dependent core laboratory and analyzed by 2 experienced cardiologists who were blinded to randomization of the patients.

Statistical Analysis

Based on the results of National Registry of Myocardial Infarction-3/4 analysis with the median total D2B time reaching 180 minutes,[5]
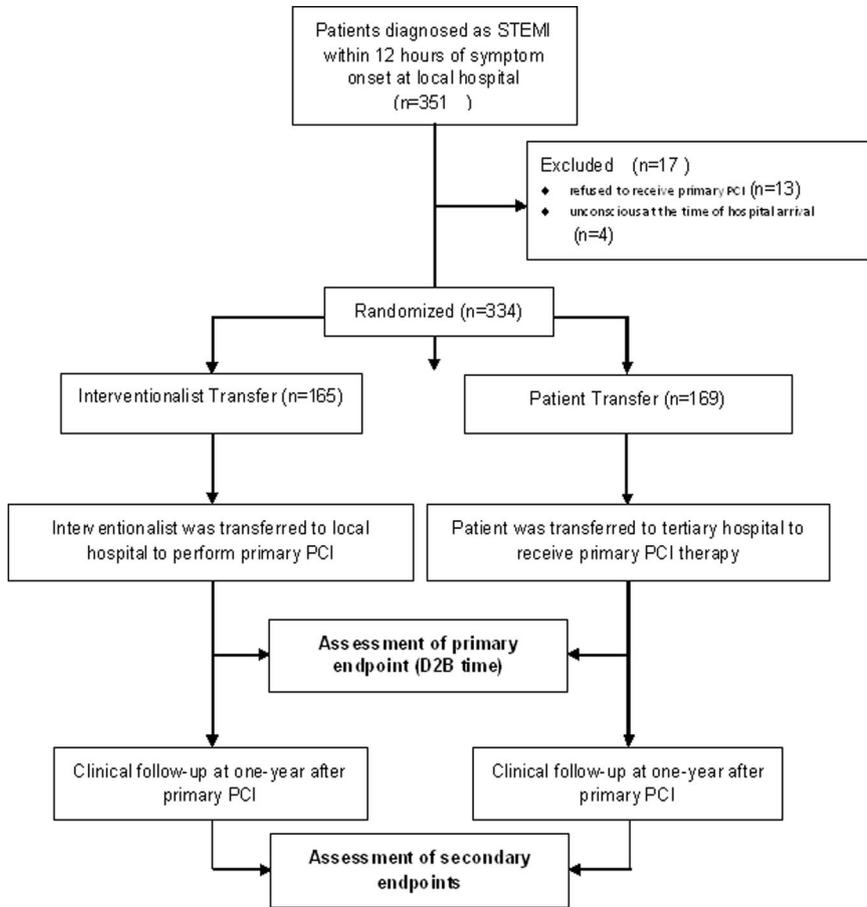
Figure 1. Study flowchart. D2B indicates door to balloon; PPCI, primary percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

we hypothesized a 15% reduction in D2B time in the patient-transfer group because of the intracity transfer property and a 30% reduction in the interventionalist-transfer group. Accordingly, a total sample size of 362 patients (161 in each group) would provide 90% power to detect a difference with α=0.05, suggesting the robustness of our results.

Data are presented as mean±SD unless otherwise indicated. Continuous variables were compared using the Student t test or

Figure 2. Location of referral hospitals and tertiary center.

Wilcoxon rank sum test, and categorical variables were compared using the Fisher exact test. A 2-sided $P<0.05$ was accepted as significance. The MACE-free survival rate at 1-year follow-up was estimated with the Kaplan-Meier method, and the difference was assessed by the log-rank test. Univariate analysis and multivariable Cox proportional hazards modeling were used to determine the crude and adjusted hazard ratios of the interventionalist-transfer strategy for composite MACE at 1-year follow-up both in the overall population and in the subgroups. In detail, the multivariable Cox model regressed treatment effect, through the backward method with P for removal of <0.1, on all baseline demographic, clinical, and angiographic covariates, including age, sex, diabetes, hypertension, hypercholesterolemia, smoking, previous MI, previous PCI, heart rate, systolic blood pressure and Killip class at presentation, location of culprit vessel, degree of coronary artery disease, TIMI flow of the IRA before and after procedure, use of glycoprotein IIb/IIIa inhibitor, D2B time, and distance from a referral hospital to the tertiary hospital. Finally, the type of transfer strategy was modeled as an independent binary variable, and hazard ratios and 95% CIs were calculated. Data management and statistical analyses were conducted using SPSS version 10.0 (SPSS Inc; Chicago, IL) software.

Results

Baseline Characteristics and Medications
Baseline characteristics were not significantly different between the interventionalist- and patient-transfer groups, and medications at the end of 1-year follow-up were similar (Table 1). In the interventionalist- and patient-transfer groups, 78 (47.3%) and 85 (50.3%) patients were self-transported to the referral hospitals, respectively ($P=0.58$), and the remaining patients were brought in by ambulance.
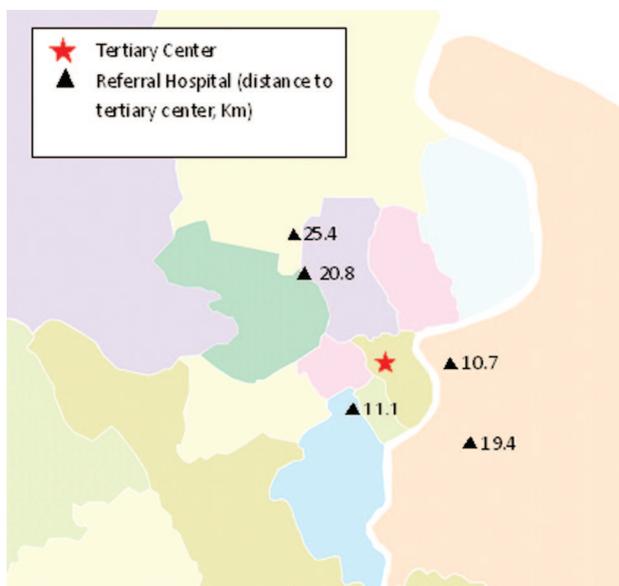
Table 1.   Baseline Characteristics and Medications

Variable	Interventionalist-Transfer Group (n=165)	Patient-Transfer Group (n=169)	P
Age, y	65.1±10.3	63.9±11.1	0.41
Male sex	100	97	0.55
Aged >65 years	73	71	0.68
Diabetes mellitus	35	41	0.51
Hypertension	117	125	0.53
Hypercholesterolemia	56	62	0.60
Current smoker	68	59	0.24
Previous MI	31	23	0.20
Previous PCI	13	11	0.63
HR at presentation, beats/min	101±22	89±28	0.11
Anterior infarction	110	103	0.28
Multivessel disease	99	98	0.71
Systolic blood pressure, mm Hg	133±28	123±31	0.29
Killip class			
I	79	72	0.33
II	54	63	0.38
III	25	29	0.62
IV	7	5	0.53
Medication*			
Patients	160 (155)	163 (151)	0.79 (0.17)
Aspirin	159 (154)	163 (147)	0.31 (0.21)
Clopidogrel	160 (145)	163 (141)	NA (0.95)
β-blockers	89 (101)	83 (97)	0.40 (0.91)
ACE inhibitors	99 (93)	110 (102)	0.29 (0.19)
Angiotensin-receptor blockers	27 (32)	22 (29)	0.40 (0.78)
Calcium antagonists	19 (21)	19 (17)	0.95 (0.61)
Nitrates	49 (28)	37 (23)	0.11 (0.54)
Diuretics	31 (9)	29 (15)	0.71 (0.21)
Statins	151 (141)	156 (134)	0.58 (0.57)
Digitalis	7 (11)	11 (19)	0.35 (0.13)

Data are presented as counts or mean±SD. ACE indicates angiotensin-converting enzyme; HR, heart rate; MI, myocardial infarction; PCI, percutaneous coronary intervention; NA, not available.

*Numbers at 1-year follow-up are indicated in parenthesis.

D2B Time and PPCI

With the interventionalist-transfer strategy, the D2B time was significantly reduced (median, 92 minutes versus 141 minutes; $P<0.0001$), and more patients had first balloon angioplasty within 90 minutes (21.2% versus 7.7%, $P<0.001$) (Table 2). The treatment delay with the patient-transfer strategy (median, 49 minutes) was mainly due to extra time consumed on waiting for ambulance arrival at the local hospital (median, 21 minutes) and transferring the patient from emergency department to the catheterization laboratory in the tertiary hospital (median, 15 minutes).

Both the interventionalist- and the patient-transfer groups did not differ significantly with respect to use of tirofiban

Table 2.   Time to Reperfusion Treatment

Variable	Interventionalist-Transfer Group (n=165)	Patient-Transfer Group (n=169)	P
Symptom onset to local hospital, min	211 (264±156)	185 (241±167)	0.38
Diagnosis to randomization, min	29 (29±6)	28 (28±6)	0.25
Call ambulance to local hospital, min	…	21 (22±7)	NA
Interventionist or patient transfer time, min	33 (34±5)	35 (35±4)	0.08
Arrival at tertiary-care hospital to catheter laboratory, min	…	15 (15±3)	NA
Door to balloon, min	92 (95±20)	141 (147±29)	<0.0001
Door to balloon <90 min, n (%)	35 (21.2)	13 (7.7)	<0.001

Data are presented as median (mean±SD), unless otherwise indicated. NA indicates not available.

(66.1% versus 56.2%) and angiographic features, except for more TIMI flow grade 3 of the IRA in the interventionalist-transfer group (17.6% versus 10.1%, $P<0.05$). Stent implantation of the IRA during PPCI (80.6% versus 84.6%) or elective PCI before discharge was similar in the 2 groups. Drug-eluting stents were implanted in 96.2% and 100% of patients in the interventionalist- and patient-transfer groups, respectively, during PPCI ($P=0.10$).

Follow-Up Outcomes

During 1-year clinical follow-up, 10 patients in the interventionalist-transfer group and 18 in the patient-transfer group died; death occurred during the first 30 days in 6 and 10 patients, respectively. Recurrence of nonfatal MI occurred in 5 and 11 patients at 30 days and in 9 and 18 patients at 1-year follow-up in the interventionalist- and patient-transfer groups, respectively (Table 3). The 1-year MACE-free survival was significantly improved with interventionalist-transfer strategy (84.8% versus 74.6%, $P=0.019$) (Figure 3). Left ventricular ejection fraction was significantly higher in the interventionalist-transfer group than in the patient-transfer group during hospitalization and at 6-month and 1-year follow-up (Figure 4). The multivariate Cox proportional hazards model showed that D2B time (>90 minutes) continued to predict MACE at 1 year (hazard ratio, 2.24; 95% CI, 1.27 to 3.96; $P=0.02$), and the interventionalist-transfer strategy was an independent factor for reduced risk of MACE in overall patients (hazard ratio, 0.63; 95% CI, 0.45 to ≈0.88; $P=0.003$) and significantly improved 1-year clinical outcomes in patients with Killip class III to IV, multivessel disease, anterior infarction, female sex, and aged >65 years (Figure 5). However, distance from a referral hospital to tertiary center (<20 km) did not enter the final model ($P=0.51$).

Discussion

How to optimize the STEMI caring system in a large metropolitan region remains different from the system for a

Table 3. Clinical Outcomes at One-Year Follow-Up

Variables	Interventionalist-Transfer Group (n=165)	Patient-Transfer Group (n=169)	P Value
Death, n (%)	10 (6.1)	18 (10.7)	0.17
Cardiac death	9 (5.5)	16 (9.5)	0.21
Non-cardiac death	1(0.6)	2 (1.2)	0.58
Non-fatal reinfarction, n (%)	9 (5.5)	18 (10.7)	0.11
TVR, n (%)	8 (4.8)	10 (5.9)	0.81
PCI	8 (5.0)	9 (5.3)	0.84
CABG	0	1 (0.6)	0.32
MACE, n (%)	25 (15.2)	43 (25.4)	0.02
Stent thrombosis, n (%)	4 (2.4)	5 (3.0)	0.76
Definite	2 (1.2)	2 (1.2)	0.98
Possible	1 (0.6)	1 (0.6)	0.99
Probable	1 (0.6)	2 (1.2)	0.58

Data are presented as n (%). PCI indicates percutaneous coronary intervention; TVR, target vessel revascularization; CABG, coronary artery bypass grafting; and MACE, major adverse cardiac events.

rural geography of hospitals separated by >50 miles.[1] In the current study, we evaluated the effects of an interventionalist-transfer strategy for PPCI in Shanghai, China, where 17 million inhabitants and 31 hospitals qualified for PPCI existed at the time of the study. The results of this study demonstrated that interventionalist-transfer strategy is superior to patient-transfer strategy in reducing D2B and improving 1-year clinical outcome for patients with STEMI undergoing PPCI.

### Primary PCI and Transfer Strategy

Over the past decade, PPCI has been recommended as the default reperfusion strategy,[2,3,12] and various models have been proposed in the system of care for patients with STEMI.[13,14] For those presenting to a PPCI-capable hospital with experienced interventional cardiologists, clinical pathways with bypassing cardiac ward stay[15,16] and direct ambulance-to-catheterization laboratory transfer[17] have been implemented to shorten the D2B time. However, in real-world practice, only a minority of patients with STEMI are admitted directly to PPCI-capable hospitals,[13] and PPCI may not be available in many hospitals because of geographical reasons and lack of PCI-qualified physicians.[4,14,16] For patients presenting to non-PPCI-capable hospitals, an interhospital patient-transfer strategy was suggested.[18]

The REVERSE-STEMI study was conducted to prospectively compare the effects of PPCI with an interventionalist-transfer strategy versus a routine patient-transfer approach for patients with STEMI who present to a non-PPCI-capable hospital. Of note, all local hospitals in the current study were equipped with angiographic facilities and PCI materials and had nurses and paramedic personnel adequately trained to provide care for patients with STEMI and their acute problems. With interventionalist-transfer strategy, the experienced interventionalists in a tertiary hospital were on standby 24 hours/day, 7 days/week, and they could go directly to the local hospitals by taxi or private automobile once they received an emergency call. At the same time, the patient started to be loaded with aspirin and clopidogrel, or intravenous glycoprotein IIb/IIIa inhibitor (tirofiban) if necessary. Likewise, patients could be sent to the catheterization laboratory and an arterial sheath may be inserted in the index hospital before the arrival of an experienced interventionalist. In this study, an increased rate of TIMI flow grade 3 of the IRA at initial angiogram in the interventionalist-transfer group may be, at least in part, related to earlier use of tirofiban.[7,19] Such a strategy has resulted in significantly
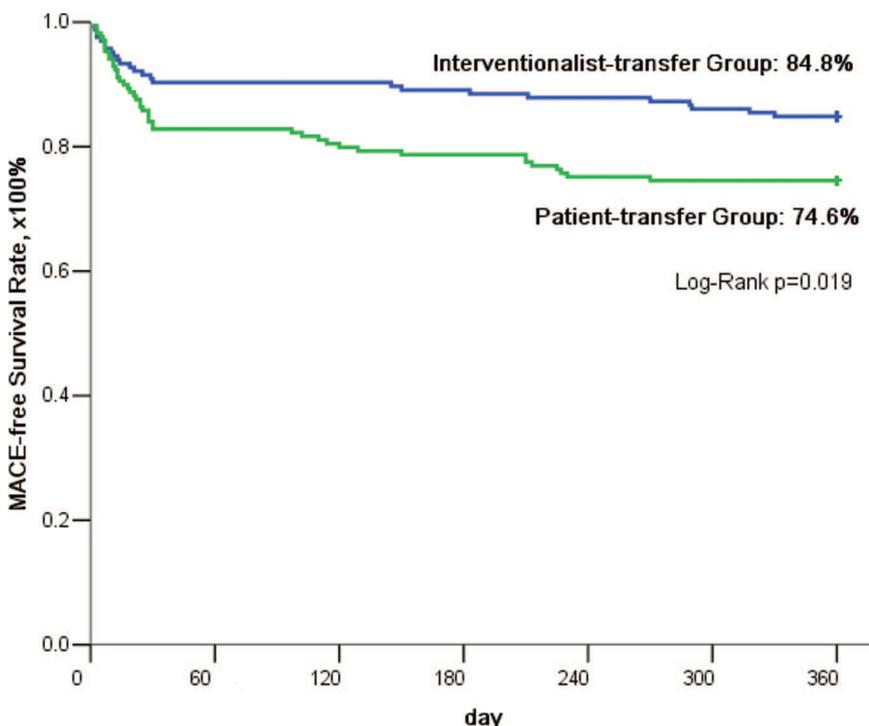
Figure 3. MACE-free survival rate at 1-year clinical follow-up. MACE indicates major adverse cardiac events.
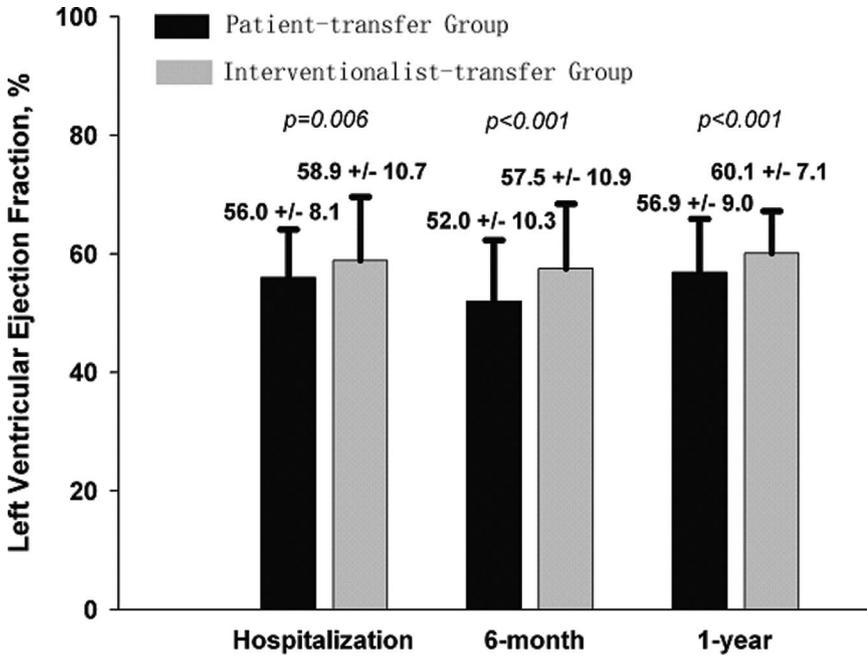
Figure 4. Left ventricular ejection fraction during hospitalization and at 6-month and 1-year follow-up.

reduced D2B time and decreased rate of MACE at 1 year. For patients with Killip class III to IV, multivessel disease, anterior infarction, female sex, and advanced age (>65 years), the interventionalist-transfer strategy also exerted a significant beneficial effect on clinical outcomes compared with the patient-transfer strategy. Multivariate analysis revealed that the interventionalist-transfer strategy was an independent factor for reduced risk of composite MACE at 1-year follow-up.

Limitations and Perspectives

This study has several limitations. First, it was powered on D2B time. Nevertheless, the results demonstrated significant differences in clinical outcomes at 1-year follow-up between the 2 treatment strategies. This observation further substan-

tiates the concept that time to treatment is an important prognostic determinant for patients with acute STEMI undergoing PPCI.[5,20] Second, the interventionalist-transfer strategy required PCI facilities or materials and nurses or paramedics adequately trained to deliver care for patients with STEMI and their acute problems in the local hospitals. Because fundamental interventionalists in the local hospitals often have insufficient training for PPCI during their fellow course, the interventionalist-transfer strategy may provide an onsite training in the index hospital by the qualified interventionalists from the tertiary centers.[4] Although onsite surgical backup was not available in 4 of the 5 referral hospitals, the safety and feasibility of PPCI in hospitals without onsite cardiac surgical backup have been demonstrated by previous studies.[21–24] Third, compared with findings in contemporary
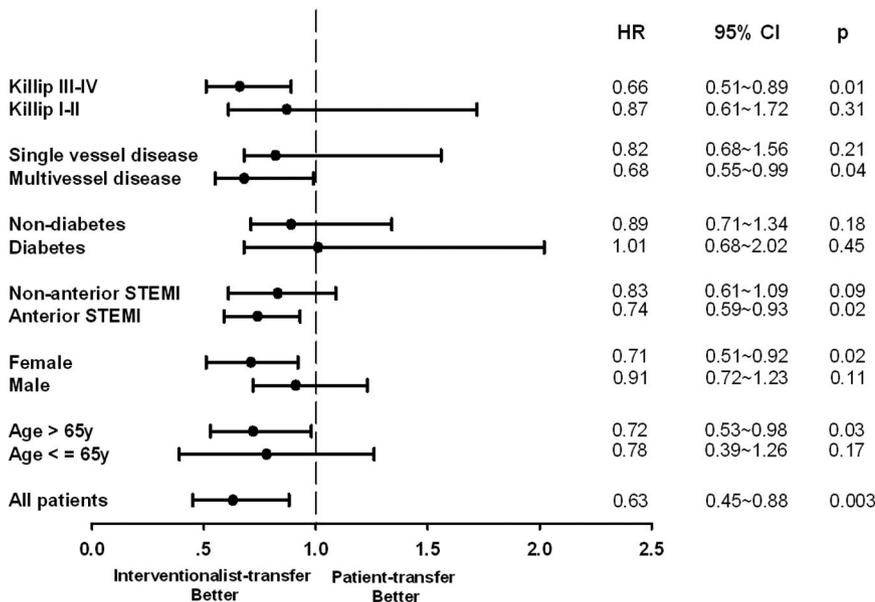
Figure 5. The effect of different transfer strategies on composite major adverse cardiac events in subgroups. HR indicates hazard ratio; STEMI, ST-segment elevation myocardial infarction.

	HR	95% CI	p
Killip III-IV	0.66	0.51~0.89	0.01
Killip I-II	0.87	0.61~1.72	0.31
Single vessel disease	0.82	0.68~1.56	0.21
Multivessel disease	0.68	0.55~0.99	0.04
Non-diabetes	0.89	0.71~1.34	0.18
Diabetes	1.01	0.68~2.02	0.45
Non-anterior STEMI	0.83	0.61~1.09	0.09
Anterior STEMI	0.74	0.59~0.93	0.02
Female	0.71	0.51~0.92	0.02
Male	0.91	0.72~1.23	0.11
Age > 65y	0.72	0.53~0.98	0.03
Age < = 65y	0.78	0.39~1.26	0.17
All patients	0.63	0.45~0.88	0.003

studies,[14,26–29] the proportion of patients with a D2B time <90 minutes was still relatively low in the interventionalist-transfer group; and glycoprotein IIb/IIIa inhibitors were not used in the patient-transfer group during ambulance transportation. Recent studies have shown that prehospital initiation of tirofiban in the ambulance was safe and beneficial for patients with acute STEMI undergoing PCI.[29] Finally, the current interventionalist-transfer strategy may be a tentative option in shortening D2B time for patients with STEMI and in physician training in a single city with hospitals located close to one another. This model may not be applied to rural geographic settings with long transfer distances.[30,31]

In the future, an improved ambulance network with direct field triage of patients with STEMI and an automated system to transmit ECGs or detailed instructions to paramedic personnel may lead to a rapid transfer of patients with possible STEMI to hospitals with a 24-hours/day, 7-days/week PPCI service, further shortening D2B time and improving the STEMI caring system in a large metropolitan region like Shanghai.[32,33]

Conclusions

PPCI with an interventionalist-transfer strategy may be a useful approach to improve the care of patients with STEMI presenting to a non-PPCI-capable hospital, particularly in a congested metropolitan region where patient transfers could be prolonged.

Sources of Funding

Disclosures

None.

References

1. Ting HH, Rihal CS, Gersh BJ, Haro LH, Bjerke CM, Lennon RJ, Lim CC, Bresnahan JF, Jaffe AS, Holmes DR, Bell MR. Regional systems of care to optimize timeliness of reperfusion therapy for ST-elevation myocardial infarction: the Mayo Clinic STEMI protocol. *Circulation*. 2007;116: 729–736.

2. Kushner FG, Hand M, Smith SC Jr, King SB III, Anderson JL, Antman EM, Bailey SR, Bates ER, Blankenship JC, Casey DE Jr, Green LA, Hochman JS, Jacobs AK, Krumholz HM, Morrison DA, Ornato JP, Pearle DL, Peterson ED, Sloan MA, Whitlow PL, Williams DO. 2009 focused updates: ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction (updating the 2004 guideline and 2007 focused update) and ACC/AHA/SCAI guidelines on percutaneous coronary intervention (updating the 2005 guideline and 2007 focused update) a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2009;54:2205–2241.

3. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. *Lancet*. 2003;361:13–20.

4. Gao RL. Shortening the door-to-balloon time for transferring primary percutaneous coronary intervention: physician transfer may be a better way in China. *Chin Med J*. 2008;121:483–484.

5. Nallamothu BK, Bates ER, Herrin J, Wang Y, Bradley EH, Krumholz HM; NRMI Investigators. Times to treatment in transfer patients undergoing primary percutaneous coronary intervention in the United States: National Registry of Myocardial Infarction (NRMI)-3/4 analysis. *Circulation*. 2005;111:761–767.

6. Huynh T, O'Loughlin J, Joseph L, Schampaert E, Rinfret S, Afilalo M, Kouz S, Cantin B, Nguyen M, Eisenberg MJ; AMI-QUEBEC Study Investigators. Delays to reperfusion therapy in acute ST-segment ele-

7. vation myocardial infarction: results from the AMI-QUEBEC Study. *CMAJ*. 2006;175:1527–1532.

7. Zhang Q, Zhang RY, Qiu JP, Zhang JF, Wang XL, Jiang L, Liao ML, Zhang JS, Hu J, Yang ZK, Shen WF. Prospective multicenter randomized trial comparing physician versus patient transfer for primary percutaneous coronary intervention in acute ST-segment elevation myocardial infarction. *Chin Med J*. 2008;121:485–491.

8. Aversano T, Aversano LT, Passamani E, Knatterud GL, Terrin ML, Williams DO, Forman SA; Atlantic Cardiovascular Patient Outcomes Research Team (C-PORT). Thrombolytic therapy vs primary percutaneous coronary intervention for myocardial infarction in patients presenting to hospitals without on-site cardiac surgery: a randomized controlled trial. *JAMA*. 2002;287:1943–1951.

9. Smith SC Jr, Feldman TE, Hirshfeld JW Jr, Jacobs AK, Kern MJ, King SB III, Morrison DA, O'Neil WW, Schaff HV, Whitlow PL, Williams DO, Antman EM, Adams CD, Anderson JL, Faxon DP, Fuster V, Halperin JL, Hiratzka LF, Hunt SA, Nishimura R, Ornato JP, Page RL, Riegel B; American College of Cardiology/American Heart Association Task Force on Practice Guidelines; ACC/AHA/SCAI Writing Committee to Update 2001 Guidelines for Percutaneous Coronary Intervention. ACC/AHA/SCAI 2005 guideline update for percutaneous coronary intervention: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/SCAI Writing Committee to Update 2001 Guidelines for Percutaneous Coronary Intervention). *Circulation*. 2006;113:e166–e286.

10. Cutlip DE, Windecker S, Mehran R, Boam A, Cohen DJ, van Es GA, Steg PG, Morel MA, Mauri L, Vranckx P, McFadden E, Lansky A, Hamon M, Krucoff MW, Serruys PW; Academic Research Consortium. Clinical end points in coronary stent trials: a case for standardized definitions. *Circulation*. 2007;115:2344–2351.

11. Schiller NB, Shah PM, Crawford M, DeMaria A, Devereux R, Feigenbaum H, Gutgesell H, Reichek N, Sahn D, Schnittger I. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. American Society of Echocardiography Committee on Standards, Subcommittee on Quantitation of Two-Dimensional Echocardiograms. *J Am Soc Echocardiogr*. 1989;2:358–367.

12. Zeymer U, Schröder R, Machnig T, Neuhaus KL. Primary percutaneous transluminal coronary angioplasty accelerates early myocardial reperfusion compared to thrombolytic therapy in patients with acute myocardial infarction. *Am Heart J*. 2003;146:686–691.

13. Mehta RH, Bufalino VJ, Pan W, Hernandez AF, Cannon CP, Fonarow GC, Peterson ED; American Heart Association Get With the Guidelines Investigators. Achieving rapid reperfusion with primary percutaneous coronary intervention remains a challenge: insights from American Heart Association's Get With the Guidelines program. *Am Heart J*. 2008;155: 1059–1067.

14. Danchin N. Systems of care for ST-segment elevation myocardial infarction: impact of different models on clinical outcomes. *J Am Coll Cardiol Cardiovasc Interv*. 2009;2:901–908.

15. Zhang Q, Zhang RY, Qiu JP, Jin HG, Zhang JF, Wang XL, Jiang L, Liao ML, Hu J, Ding FH, Zhang JS, Shen WF. Impact of different clinical pathways on outcomes of patients with acute ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention: the RAPID-AMI study. *Chin Med J*. 2009;122:636–642.

16. Manari A, Ortolani P, Guastaroba P, Casella G, Vignali L, Varani E, Piovaccari G, Guiducci V, Percoco G, Tondi S, Passerini F, Santarelli A, Marzocchi A. Clinical impact of an inter-hospital transfer strategy in patients with ST-elevation myocardial infarction undergoing primary angioplasty: the Emilia-Romagna ST-segment elevation acute myocardial infarction network. *Eur Heart J*. 2008;29:1834–1842.

17. van de Loo A, Saurbier B, Kalbhenn J, Koberne F, Zehender M. Primary percutaneous coronary intervention in acute myocardial infarction: direct transportation to catheterization laboratory by emergency teams reduces door-to-balloon time. *Clin Cardiol*. 2006;29:112–116.

18. Dalby M, Bouzamondo A, Lechat P, Montalescot G. Transfer for primary angioplasty versus immediate thrombolysis in acute myocardial infarction: a meta-analysis. *Circulation*. 2003;108:1809–1814.

19. Shen J, Zhang Q, Zhang RY, Zhang JS, Hu J, Yang ZK, Zheng AF, Zhang X, Shen WF. Clinical benefits of adjunctive tirofiban therapy in patients with acute ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention. *Coro Artery Dis*. 2008;19: 271–277.

20. Nallamothu BK, Bradley EH, Krumholz HM. Time to treatment in primary percutaneous coronary intervention. *N Engl J Med*. 2007;357: 1631–1638.

21. Peels HO, de Swart H, Ploeg TV, Hautvast RW, Cornel JH, Arnold AE, Wharton TP, Umans VA. Percutaneous coronary intervention with off-site cardiac surgery backup for acute myocardial infarction as a strategy to reduce door-to-balloon time. *Am J Cardiol*. 2007;100: 1353–1358.

22. Carlsson J, James SN, Ståhle E, Höfer S, Lagerqvist B. Outcome of percutaneous coronary intervention in hospitals with and without on-site cardiac surgery standby. *Heart*. 2007;93:335–338.

23. Dehmer GJ, Kutcher MA, Dey SK, Shaw RE, Weintraub WS, Mitchell K, Brindis RG; ACC-NCDR. Frequency of percutaneous coronary interventions at facilities without on-site cardiac surgical backup—a report from the American College of Cardiology-National Cardiovascular Data Registry (ACC-NCDR). *Am J Cardiol*. 2007;99:329–332.

24. Ting HH, Raveendran G, Lennon RJ, Long KH, Singh M, Wood DL, Gersh BJ, Rihal CS, Holmes DR Jr. A total of 1,007 percutaneous coronary interventions without onsite cardiac surgery: acute and long-term outcomes. *J Am Coll Cardiol*. 2006;47:1713–1721.

25. Danchin N, Coste P, Ferrières J, Steg PG, Cottin Y, Blanchard D, Belle L, Ritz B, Kirkorian G, Angioi M, Sans P, Charbonnier B, Eltchaninoff H, Guéret P, Khalife K, Asseman P, Puel J, Goldstein P, Cambou JP, Simon T; FAST-MI Investigators. Comparison of thrombolysis followed by broad use of percutaneous coronary intervention with primary percutaneous coronary intervention for ST-segment-elevation acute myocardial infarction: data from the french registry on acute ST-elevation myocardial infarction (FAST-MI). *Circulation*. 2008;118:268–276.

26. Cantor WJ, Fitchett D, Borgundvaag B, Ducas J, Heffernan M, Cohen EA, Morrison LJ, Langer A, Dzavik V, Mehta SR, Lazzam C, Schwartz B, Casanova A, Goodman SG; TRANSFER-AMI Trial Investigators. Routine early angioplasty after fibrinolysis for acute myocardial infarction. *N Engl J Med*. 2009;360:2705–2718.

27. Di Mario C, Dudek D, Piscione F, Mielecki W, Savonitto S, Murena E, Dimopoulos K, Manari A, Gaspardone A, Ochala A, Zmudka K, Bolognese L, Steg PG, Flather M; CARESS-in-AMI (Combined Abciximab RE-teplase Stent Study in Acute Myocardial Infarction) Investigators. Immediate angioplasty versus standard therapy with rescue angioplasty after thrombolysis in the Combined Abciximab REteplase Stent Study in Acute Myocardial Infarction (CARESS-in-AMI): an open, prospective, randomised, multicentre trial. *Lancet*. 2008;371:559–568.

28. Bradley EH, Nallamothu BK, Herrin J, Ting HH, Stern AF, Nembhard IM, Yuan CT, Green JC, Kline-Rogers E, Wang Y, Curtis JP, Webster TR, Masoudi FA, Fonarow GC, Brush JE Jr, Krumholz HM. National efforts to improve door-to-balloon time results from the Door-to-Balloon Alliance. *J Am Coll Cardiol*. 2009 15;54:2423–2429.

29. Van't Hof AW, Ten Berg J, Heestermans T, Dill T, Funck RC, van Werkum W, Dambrink JH, Suryapranata H, van Houwelingen G, Ottervanger JP, Stella P, Giannitsis E, Hamm C; Ongoing Tirofiban In Myocardial infarction Evaluation (On-TIME) 2 Study Group. Prehospital initiation of tirofiban in patients with ST-elevation myocardial infarction undergoing primary angioplasty (On-TIME 2): a multicentre, double-blind, randomised controlled trial. *Lancet*. 2008;372:537–546.

30. Widimský P, Budesínský T, Vorác D, Groch L, Zelízko M, Aschermann M, Branny M, St'ásek J, Formánek P; 'PRAGUE' Study Group Investigators. Long distance transport for primary angioplasty vs immediate thrombolysis in acute myocardial infarction. Final results of the randomized national multicentre trial—PRAGUE-2. *Eur Heart J*. 2003;24: 94–104.

31. Giuliani G, Bonechi F, Vecchio S, Biondi-Zoccai GG, Nieri M, Vittori G, Spaziani G, Nassi F, Chechi T, Di Mario C, Zipoli A, Margheri M. Comparison of primary angioplasty in rural and metropolitan areas within an integrated network. *EuroIntervention*. 2008;4:365–372.

32. Baruch T, Rock A, Koenig WJ, Rokos I, French WJ. "Call 911" STEMI protocol to reduce delays in transfer of patients from non primary percutaneous coronary intervention referral Centers. *Crit Pathw Cardiol*. 2010;9:113–115.

33. Rokos IC, French WJ, Koenig WJ, Stratton SJ, Nighswonger B, Strunk B, Jewell J, Mahmud E, Dunford JV, Hokanson J, Smith SW, Baran KW, Swor R, Berman A, Wilson BH, Aluko AO, Gross BW, Rostykus PS, Salvucci A, Dev V, McNally B, Manoukian SV, King SB III. Integration of pre-hospital electrocardiograms and ST-elevation myocardial infarction receiving center (SRC) networks: impact on door-to-balloon times across 10 independent regions. *J Am Coll Cardiol Cardiovasc Interv*. 2009;2:339–346.

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