


# Long-term outcomes of delayed percutaneous coronary intervention for patients with ST-segment elevation myocardial infarction

## A propensity score-matched retrospective study

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### Abstract

The best time window of percutaneous coronary intervention (PCI) is within 12 hours for ST-segment elevation myocardial infarction (STEMI). However, there is limited evidence about the proper time of PCI for delayed STEMI patients.

From June 2014 to June 2015, a total of 268 patients receiving PCI with second-generation drug-eluting stent in a Chinese hospital after 3 days of STEMI onset were enrolled in this retrospective study, who were divided into the early group (3–14 days) and the late group (>14 days). A propensity score match was conducted to reduce the baseline difference. The primary endpoint of all-cause death and secondary endpoints of major adverse cardiac and cerebrovascular event (myocardial infarction [MI], stroke, emergent revascularization, and rehospitalization due to heart failure) were compared using survival analysis.

At last, 182 cases were matched after propensity score match, with no statistical difference in baseline characteristics and PCI data. Kaplan-Meier survival curve demonstrated no difference in all-cause death of the 2 groups ( $P = .512$ ). However, the early group presented a higher incidence of MI than the late group ( $P = .036$ ). The multivariate Cox regression analysis also demonstrated that the early PCI was an independent risk factor for MI compared with late PCI (hazard ratio = 3.83, 95%CI [1.91–8.82],  $P = .001$ ). There was no statistical difference in other major adverse cardiac and cerebrovascular event, including stroke, emergent revascularization, and rehospitalization due to heart failure.

Using the 2<sup>nd</sup> drug-eluting stent, early PCI (3–14 days) and late PCI (>14 days) have comparable efficacy and outcomes. However, patients receiving early PCI are subjected to a relatively higher risk of recurrent MI.

**Abbreviations:** CAD = coronary artery disease, DES = drug-eluting stent, HR = hazard ratio, MACCE = major adverse cardiac and cerebrovascular event, MI = myocardial infarction, PCI = percutaneous coronary intervention, PSM = propensity score match, STEMI = ST-segment elevation myocardial infarction.

**Keywords:** percutaneous coronary intervention, propensity score match, second-generation drug-eluting stents, ST-elevated myocardial infarction

## 1. Introduction

Although the survival rates have increased in recent years, ST-segment elevation myocardial infarction (STEMI), as one manifestation of coronary artery disease (CAD), remains the most threatening cardiovascular disease, contributing to morbidity and mortality worldwide.<sup>[1]</sup> The key points for dealing with STEMI are early diagnosis and immediate reperfusion to

limit myocardial ischemia and infarct size and thereby reduce the risk of post-STEMI complications including heart failure.<sup>[2]</sup> Due to the development of prevention and treatment, the 6-month mortality after acute myocardial infarction (MI) has decreased considerably for patients with STEMI and Non-ST-segment elevation myocardial infarction over the past 20 years.<sup>[3]</sup> As the acute treatment, percutaneous coronary intervention (PCI) can

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recover the perfusion, reduce the infarct area, and save the myocardium, dramatically increasing the outcome and prognosis of patients with STEMI.<sup>[4]</sup> However, the timing of PCI remains controversial in many aspects. It is believed that the best time of PCI is within 12 hours after the onset of STEMI.<sup>[5]</sup> In China, there were still many patients who missed the best time window for PCI due to some reasons, including misdiagnosis, rural areas, and lack of medical resources. Notably, PCI is still of great value in improving outcomes after the golden time window. The 2017 European Society of Cardiology (ESC) Guidelines for managing acute MI in patients presenting with ST-segment elevation have expanded the beneficial population to the patients receiving PCI within 48 hours.<sup>[6]</sup>

However, there are controversies on the treatment strategy for those patients missing early perfusion. An early study demonstrated no benefit of PCI over medication in stable post-MI patients with late occluded infarct-related arteries.<sup>[7]</sup> In contrast, another meta-analysis found that late revascularization of an occluded infarct-related artery may improve left ventricular systolic function and remodeling, supporting the “open artery hypothesis”.<sup>[8]</sup> Xiu et al<sup>[9]</sup> also reported that PCI for STEMI delayed beyond 12 hours after the onset of symptoms can better reduce mortality and the incidence of Major adverse cardiac events (MACEs), compared with medication therapy. Second-generation drug-eluting stents (DESs) have the advantages of excellent biocompatibility, less inflammatory response, and faster vessel endothelialization, which has gained popularity in clinical practice. A study found that the use of second-generation DES was associated with lower risk of long-term all-cause mortality, in stent restenosis and stent thrombosis as compared with first-generation DES in patients with chronic kidney disease.<sup>[10]</sup> However, previous studies focusing on the time point for patients missing out on the emergent PCI did not use the 2<sup>nd</sup> DES. Also, there was limited evidence about the efficacy of early and late revascularization therapy. This study aimed to compare the long-term outcomes of STEMI patients treated with the early and late PCI with 2<sup>nd</sup> DES.

## 2. Methods

### 2.1. Patients

The patients were enrolled from the hospital CAD registry database retrospectively. All patients included were required to fulfill the following criteria: age  $\geq 18$  years; diagnosis with STEMI based on coronary angiography; the patient received revascularization treatment of PCI with 2<sup>nd</sup> DES in our hospital; the period between STEMI onset and PCI was more than 3 days; the patient remained alive during the hospital stay; the patient had complete clinical data and follow-up data. The exclusion criteria were as follows: patients diagnosed with non-ST elevation MI or unstable angina; patients with severe infections, acute organ dysfunction, or other serious diseases. The enrolled patients were divided into 2 groups: the early group (the period between STEMI onset and PCI was more than 3 days but less than 14 days) and the late group (the period between STEMI onset and PCI was more than 14 days). The Medical Ethics Committee of Shanxi Dayi Hospital approved the present study. Since this was a retrospective study, the patients' consents were not required.

This study followed the 2017 ESC Guidelines for the Management of Acute Myocardial Infarction in Patients Presenting With ST-segment Elevation<sup>[6]</sup> STEMI was defined as follows: electrocardiographic ST-segment elevation  $>2$  mm in

2 or more contiguous chest leads or  $\geq 1$  mm in 2 or more limb leads or new onset of left bundle-branch block, together with chest pain or other typical symptoms and elevated troponin levels  $>99^{\text{th}}$  percentile.<sup>[6]</sup>

### 2.2. PCI procedure and in-hospital treatment

The non-PCI treatments before the delayed PCI were conducted in all patients under the guidelines.<sup>[6]</sup> If medications were not contraindicated, and the heart rate and blood pressure were not adversely affected, optimal medications were given in all patients, including dual antiplatelet drugs (aspirin and clopidogrel), anticoagulants, angiotensin-converting enzyme inhibitors,  $\beta$  receptor blockers, and lipid-lowering therapy.

Coronary angiography and PCI procedure were routinely performed, as previously described.<sup>[11]</sup> Successful PCI was defined as coronary angiography indicating residual lumen stenosis of  $<20\%$  and a blood flow classification of thrombolysis in MI grade 3 without serious complications such as acute occlusion and intra-operative death. All patients were given oral clopidogrel load 300 to 600 mg and aspirin load 300 mg before the PCI procedure. After the operation, clopidogrel should be taken orally at 75 mg/d for at least 12 months. Aspirin 100 mg/d is maintained for a long time. The anticoagulant drugs used in operation were mainly unfractionated heparin, and a few patients with a high risk of bleeding chose bivalirudin. During the operation, the operator decides whether to administer the glycoprotein IIb/IIIa receptor antagonist, use a suction catheter, and pre-dilate and postdilate the balloon. Other secondary preventive drug treatments refer to relevant guidelines and recommendations, including beta-blockers, statins, angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers, and spironolactone, according to guidelines the 2017 ESC Guidelines for the Management of Acute Myocardial Infarction in Patients Presenting With ST-segment Elevation.

### 2.3. Data collection

Clinical data were collected from the electronic medical record database of Shanxi Dayi Hospital, including demographic characteristics, clinical data, laboratory tests at admission, and PCI data. Follow-up was conducted routinely on every patient receiving PCI in the hospital. Follow-up contents including the survival status, the most recent hospital admission and reason. If the patient got re-admitted in the Shanxi Dayi Hospital, the in-hospital information would be recorded. The follow-up in outpatient clinic was required at 3 months, 6 months, and 1 year after discharge for the patients. If the follow-up cannot be fulfilled, it would be conducted on telephone interview.

### 2.4. Clinical endpoints

The primary endpoint was defined as all-cause mortality during follow-up, and the secondary endpoint was a composite of major adverse cardiac and cerebrovascular events (MACCEs), including MI, stroke, unscheduled revascularization and rehospitalization due to heart failure. Two researchers, respectively, had verified all endpoints of the patients.

### 2.5. Follow-up

The adverse events of the enrolled patients were followed up. They were revisited in the outpatient clinics at 1, 3, and 6 months

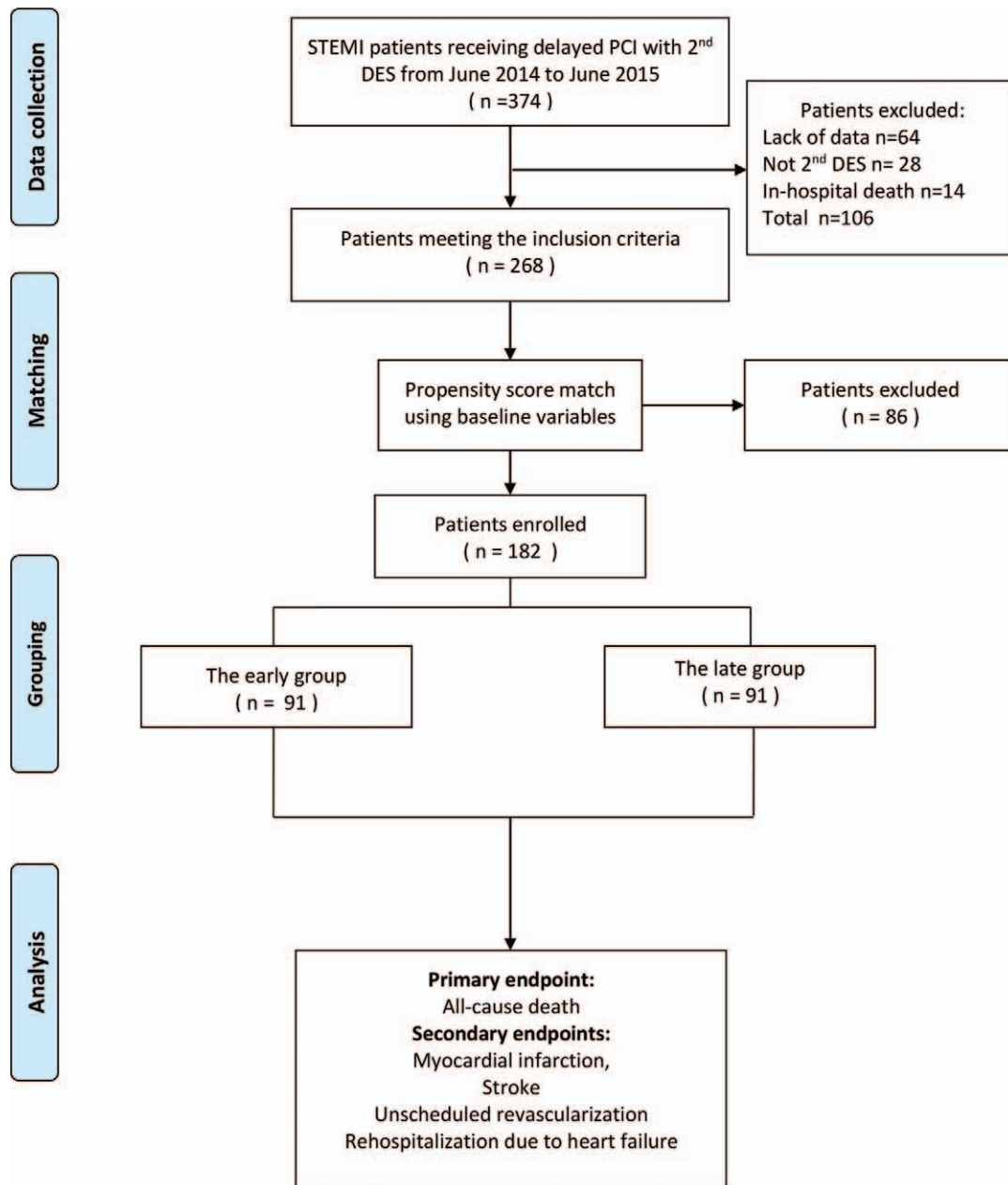
after discharge and were followed up by telephone every 6 months for 5 years. If there were any non-invasive or invasive assessments during follow-up, they would be recorded in our hospital dataset. The judgment of all adverse events was obtained with written evidence, which was checked by 2 researchers and entered into the database after reaching an agreement.

**2.6. Statistical analysis**

IBM SPSS Statistics, version 19.0 (SPSS, Inc, Armonk, NY) was used for statistical analysis in this study. The variables were first subjected to the normality of the distribution test (Kolmogorov-Smirnov test). Continuous variables following normal distribu-

tion were expressed as the mean±standard deviation, and categorical variables were presented as proportions. In contrast, continuous variables that did not fit a normal distribution were described as the median and interquartile range. A comparison of continuous variables following a normal distribution was conducted with a *t* test of independent samples. Chi-square tests were performed in different evaluations of categorical variables. Mann–Whitney *U* test was applied for comparison of the continuous variable not following the normal distribution.

The propensity score was calculated with multivariable logistic regression by considering demographical and clinical variables (age, gender, body mass index, left ventricular ejection fraction,



**Figure 1.** Flowchart of the study design. DES = drug-eluting stent, PCI = percutaneous coronary intervention, STEMI = ST-segment elevation myocardial infarction.

smoking, and comorbidities). Patients with the closest propensity scores were matched using the “greedy match” method.<sup>[12]</sup> The matching ratio is 1:1, and the caliper value is set to 0.02, when the execution performance is optimized. Following the propensity score match, a Student *t* test of paired samples and a McNemar test were adopted in the analysis. As for the survival analysis, the Cox hazard ratios (HRs) model was adopted as the regression method to compare the relative HR, while Kaplan-Meier survival curves and log-rank tests were also used. A *P* value of less than .05 was considered statistically significant.

### 3. Results

#### 3.1. Baseline characteristics

From June 2014 to June 2015, a total of 374 cases of STEMI patients received delayed PCI, of whom a total of 268 cases met the inclusion criteria and were enrolled in this study, including 142 cases of early PCI treatment (3–14 days), and 126 cases of late PCI treatment (>14 days). A propensity score match (PSM)

was conducted using covariates of demographic and baseline characteristics. After PSM, there were 91 pairs of patients left for further analysis. The study design and flowchart were shown in Figure 1.

The demographic and baseline characteristics of the 2 groups were shown in Table 1 (before PSM) and Table 2 (after PSM). Before PSM, the late group presented significantly higher age, body mass index, left ventricular ejection fraction, peak cardiac troponin T, higher transfer rate, and thrombosis treatment (all *P* < .05). However, there was no significant difference between the 2 groups in all variables of baseline characteristics after PSM (all *P* > .05).

#### 3.2. PCI data

As shown in Table 3, we compared the data of the PCI procedure of the early group and the late group. Both groups had comparable lesion vessel type, the culprit artery, the pre-operative thrombolysis in myocardial infarction grade, and the number of

**Table 1**  
Demographical characteristics and clinical data of the early group and the late group before PSM.

Variables	The early group (n = 142)	The late group (n = 126)	<i>P</i> value
Demographics			
Age (yr, mean ± SD)	54.5 ± 12.4	59.5 ± 13.1	.002
Gender (%male)	104 (73.2%)	82 (57.7%)	.148
BMI (kg/m <sup>2</sup> )	23.8 ± 4.5	26.1 ± 3.8	<.001
Smoking (n, %)	57 (40.1%)	40 (31.7%)	.154
Echocardiography			
LVEF (%)	46.8 ± 8.9	51.5 ± 12.4	<.001
FS (%)	24.5 ± 5.4	30.1 ± 6.8	<.001
LVDd (mm)	55.3 ± 6.1	51.2 ± 4.8	<.001
LVDs (mm)	36.4 ± 5.2	33.3 ± 4.2	<.001
NYHA grade			.211
I	21 (14.8%)	28 (22.2%)	
II	45 (31.7%)	44 (35.7%)	
III	66 (46.5%)	45 (34.9%)	
IV	10 (7.0%)	9 (7.1%)	
Comorbidities			
Heart failure	45 (31.7%)	48 (38.1%)	.272
Hypertension	33 (23.2%)	40 (31.4%)	.119
Diabetes mellitus	19 (13.4%)	12 (9.5%)	.325
Chronic kidney disease	12 (8.5%)	8 (6.3%)	.514
Chronic lung disease	19 (13.4%)	18 (14.3%)	.830
Cerebrovascular disease	3 (2.1%)	1 (0.8%)	.625
Tumor	2 (1.4%)	0 (0)	.500
Laboratory test at admission			
Peak cTnT (ng/dL)	6.40 (4.59,8.26)	7.58 (4.87,9.27)	.026
Peak CK-MB (ng/dL)	551 (334.75,774.25)	612 (411,800.75)	.143
Creatinine (μmol/L)	104 (78,130.25)	101 (71.75,145.5)	.997
NT-proBNP (ng/L)	89.7 (58.88,117.88)	85.75 (57.8,110.33)	.251
hsCRP (mg/L)	29.35 (19.75,40.83)	30.1 (22.55,36.13)	.911
SYNTAX score	29.5 (24.75,35.25)	30 (23,38)	.330
Transfer for PCI	45 (31.7%)	60 (42.2%)	.008
Thrombolysis treatment	40 (28.2%)	64 (50.8%)	<.001
Killip grade > I	20 (7.0%)	16 (6.3%)	.740

BMI=body mass index, CK-MB=creatinine kinase-MB, cTnT=cardiac troponin T, FS=fractional shortening, hsCRP=high-sensitivity C-reactive protein, LVDd=left ventricular end-diastolic dimension, LVDs=left ventricular end-systolic dimension, LVEF=left ventricular ejection fraction, NT-proBNP=NT-proB-type natriuretic peptide, NYHA=New York Heart Association, PCI = percutaneous coronary intervention, PSM = propensity score match, SD = standard deviation.

**Table 2**  
Demographical characteristics and clinical data of the early group and the late group after PSM.

Variables	The early group (n = 91)	The late group (n = 91)	<i>P</i> value
Demographics			
Age (yr, mean ± SD)	53.3 ± 10.3	51.1 ± 9.2	.129
Gender (%male)	64 (70.3%)	61 (67.0%)	.632
BMI (kg/m <sup>2</sup> )	24.2 ± 3.5	23.9 ± 4.2	.630
Smoking (n, %)	33 (36.3%)	30 (33.0%)	.640
Echocardiography			
LVEF (%)	46.2 ± 7.2	47.8 ± 8.3	.168
FS (%)	24.3 ± 4.6	25.1 ± 6.5	.250
LVDd	56.2 ± 6.2	55.3 ± 5.2	.202
LVDs	36.8 ± 5.4	35.9 ± 4.9	.156
NYHA grade			.600
I	14 (15.4%)	20 (22.0%)	
II	30 (33.0%)	32 (35.2%)	
III	42 (46.2%)	35 (38.5%)	
IV	5 (5.5%)	4 (4.4%)	
Comorbidities			
Heart failure	29 (31.9%)	33 (36.3%)	.532
Hypertension	29 (31.9%)	35 (38.5%)	.352
Diabetes mellitus	14 (15.4%)	9 (9.9%)	.265
Chronic kidney disease	8 (8.8%)	6 (6.6%)	.578
Chronic lung disease	13 (14.3%)	14 (15.4%)	.835
Cerebrovascular disease	2 (2.2%)	1 (1.1%)	.925
Tumor	2 (2.2%)	0 (0)	.497
Laboratory test at admission			
Peak cTnT (ng/dL)	6.62 (4.73,7.56)	6.33 (4.74,7.8)	.970
Peak CK-MB (ng/dL)	548 (383,784)	650 (455,834)	.143
Creatinine (μmol/L)	106 (78,126)	101 (71,129)	.710
NT-proBNP (ng/L)	89.3 (58.4,118.2)	82.7 (52.8,111.7)	.378
hsCRP (mg/L)	26.0 (18.2,34.2)	29.7 (22.8,38.1)	.079
SYNTAX score	26 (22,33)	28 (23,36)	.266
Transfer for PCI	25 (27.5%)	30 (33.0%)	.420
Thrombolysis treatment	20 (22.0%)	28 (30.8%)	.178
Killip > I grade	10 (6.6%)	8 (4.4%)	.619

BMI=body mass index, CK-MB=creatinine kinase-MB, cTnT=cardiac troponin T, FS=fractional shortening, hsCRP=high-sensitivity C-reactive protein, LVDd=left ventricular end-diastolic dimension, LVDs=left ventricular end-systolic dimension, LVEF=left ventricular ejection fraction, NT-proBNP=NT-proB-type natriuretic peptide, NYHA=New York Heart Association, PCI = percutaneous coronary intervention, PSM = propensity score match, SD = standard deviation.

**Table 3**  
**PCI data of the early group and the late group after PSM.**

Variables	The early group (n=91)	The late group (n=91)	P value
Lesion vessel (n, %)			.601
Single vessel	23 (25.3%)	26 (28.6%)	
Double vessel	36 (39.6%)	40 (44.0%)	
Triple vessel	29 (31.9%)	24 (26.4%)	
Left main trunk	3 (3.3%)	1 (1.1%)	
Culprit artery (n, %)			.663
Left anterior descending artery	51 (56.0%)	56 (61.5%)	
Left circumflex artery	8 (8.8%)	6 (6.6%)	
Right coronary artery	31 (34.1%)	29 (31.9%)	
Left main trunk	1 (1.1%)	0 (0)	
Pre-operative TIMI grade (n, %)			.130
TIMI 0	20 (22.0%)	33 (36.3%)	
TIMI I	4 (4.4%)	4 (4.4%)	
TIMI II	7 (7.7%)	1 (1.1%)	
TIMI III	60 (65.9%)	53 (58.2%)	
No. of DES	2.7 ± 1.2	2.4 ± 1.1	.108
Application of tirofiban (n, %)	17 (18.7%)	16 (17.6%)	.847

DES = drug-eluting stents, PCI = percutaneous coronary artery intervention, PSM = propensity score match, TIMI = thrombolysis in myocardial infarction.

DES stents used, as well as the percentage of application of Tirofiban (all  $P > .05$ ).

**3.3. Primary endpoint**

As shown in Figure 2A, the primary endpoint of all-cause death of 2 groups was compared with survival analysis. We found that the 2 groups had similar survival rates, with no difference in the log-rank test ( $P = .512$ ).

**3.4. Secondary endpoint**

The secondary endpoints of MACCE were shown in Figures 2B and 3, respectively. There was no difference between the 2 groups in the incidence of MACCE (log-rank test  $P = .630$ ). However,

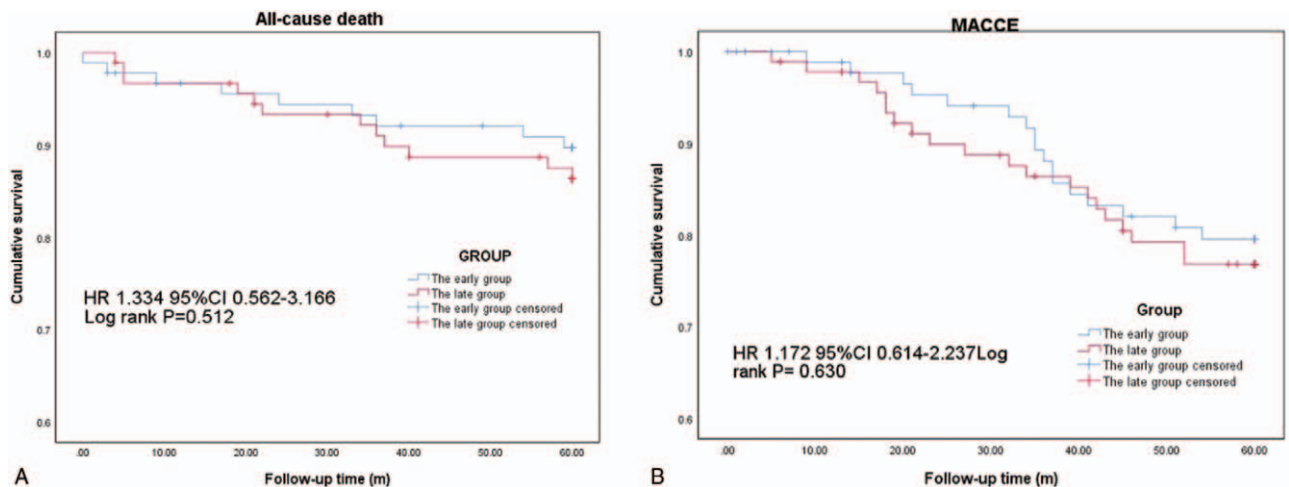
when we examined different MACCE events separately, we found that the early group demonstrated a higher incidence of recurrent MI ( $P = .036$ ). At the same time, there was no statistical difference between the 2 groups in emergent revascularization, stroke, and rehospitalization due to heart failure (all  $P > .05$ ). We conducted the Cox proportional hazards regression analysis to analyze the risk factors for MACCE (Table 4). We found that the early PCI group was subjected to a higher risk of recurrent MI (HR 3.28, 95%CI [1.68,7.61],  $P = .001$ ) than the late group.

**4. Discussion**

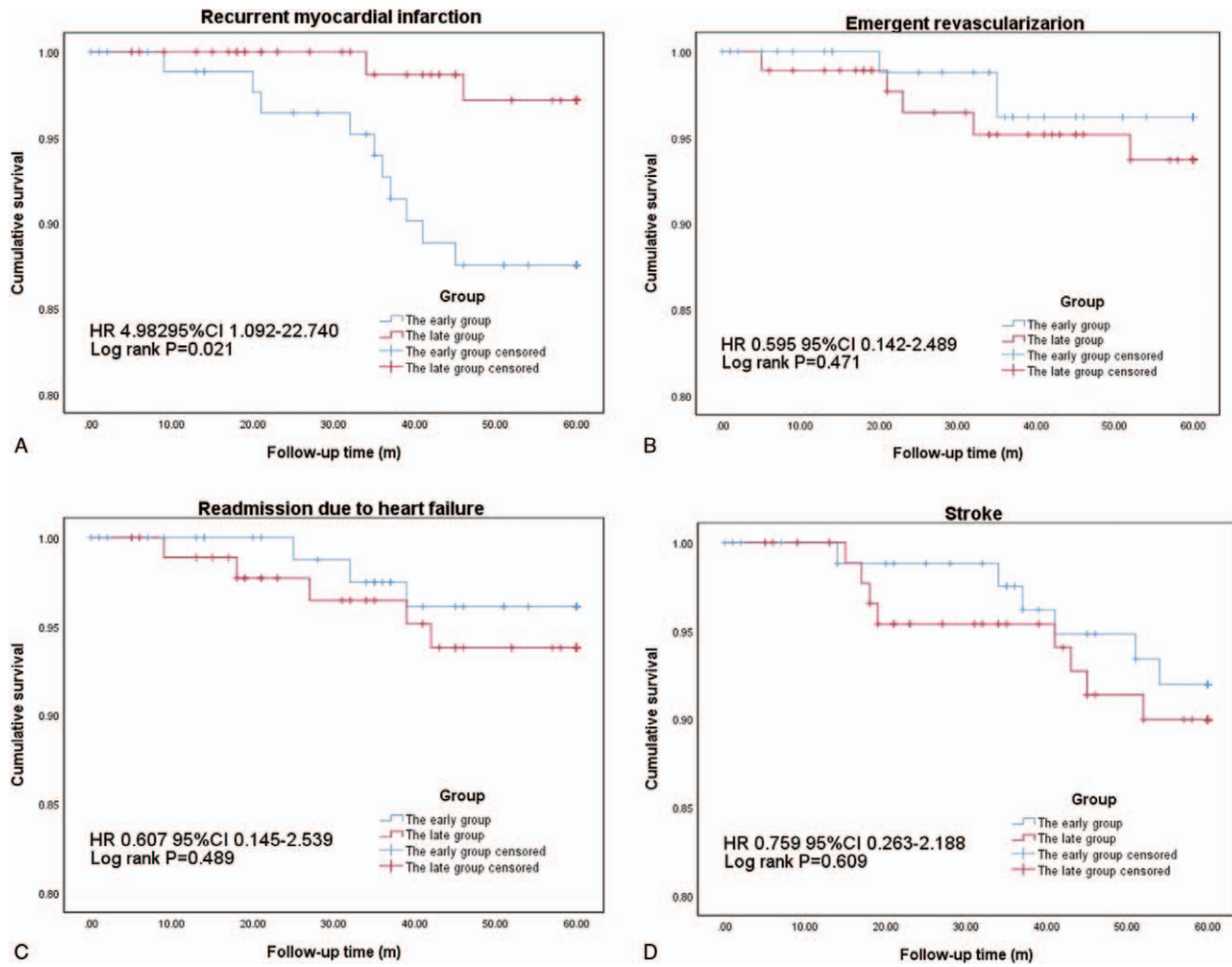
The golden time for PCI treatment is within 12 hours after STEMI onset, and the PCI procedure should be conducted as soon as possible.<sup>[13]</sup> However, many patients cannot receive revascularization treatment in the golden window due to all kinds of reasons, such as misdiagnosis, delayed transfer, or atypical symptoms. For patients who miss out on early reperfusion, there are controversies over the application of PCI or medical therapy alone. Besides, there are minimal evidence about the time of PCI for those patients, especially for their long-term outcomes.

The early Occluded Artery Trial study failed to confirm that the 3- to 28-day delayed PCI effect for stable STEMI patients is better than conservative drug treatment. Still, the study only included patients with persistent infarct-related artery occlusion, and only 8% of patients were placed with DES, which did not comply with the current clinical actual situation.<sup>[7,14]</sup> In contrast, only 53 (29%) patients were thrombolysis in myocardial infarction 0 grade, and all patients were placed with 2<sup>nd</sup> DES. Further studies have proved the significant advantages of PCI over medication alone for patients who miss out the early revascularization. A meta-analysis of 3560 patients with STEMI showed that delayed PCI (1–26 days) could prolong survival by 2.8 years compared with conservative drug treatment.<sup>[15]</sup> A meta-analysis further shows that the late opening of occlusive infarct-related arteries can improve left ventricular systolic function and ventricular remodeling.<sup>[8]</sup>

Although it has not been included in the guidelines, PCI treatment for subacute STEMI patients has gained popularity in



**Figure 2.** Kaplan-Meier survival curve of the primary endpoint and secondary endpoint. (A) Kaplan-Meier survival curve for the primary endpoint of all-cause death; (B) Kaplan-Meier survival curve for the secondary endpoint of MACCE. MACCE = major adverse cardiac and cerebrovascular event.



**Figure 3.** Kaplan-Meier survival curve of the secondary endpoints. (A) Kaplan-Meier survival curve of the recurrent myocardial infarction; (B) Kaplan-Meier survival curve of the emergent revascularization; (C) Kaplan-Meier survival curve of rehospitalization due to heart failure; (D) Kaplan-Meier survival curve of the stroke.

many cardiac centers in China. It is demonstrated that the benefits of delayed PCI include relieving persistent myocardial ischemia, rescuing dying myocardium, improving ventricular remodeling, stabilizing electrical activity, shortening hospital stays, and reducing medical expenses.<sup>[16]</sup> However, the specific time point for delayed PCI treatment remains undefined. Guo conducted a real-world retrospective cohort study with 417 STEMI patients enrolled and divided the patients into 4 groups (PCI < 3 days, 14.87%; 3 days < PCI < 7 days, 21.104%; PCI > 7 days, 34.29%;

medicine (no PCI), 29.74%). The study found that the medicine (no PCI) group had higher rates of MACEs, and the timing of the intervention was independent of the occurrence of MACEs.<sup>[15]</sup> Another study divided 5417 STEMI patients (2–28 days after STEMI) who underwent delayed PCI into the early group (2–7 days), medium group (8–14 days), and late group (15–28 days), which demonstrated that the medium group had more significant survival benefit and less adverse events.<sup>[17]</sup> Those studies only observed the MACEs during hospitalization or a 1-year follow-up.

**Table 4**  
Multivariate Cox regression analysis of secondary endpoint for the early group versus the late group.

Secondary endpoint	Unadjusted		Adjusted <sup>a</sup>	
	HR (95%CI)	P value	HR (95%CI)	P value
Myocardial infarction	3.70 (1.84,7.84)	<.001	3.83 (1.91,8.82)	.001
Stroke	1.64 (0.22,13.38)	.618	1.96 (0.26,16.31)	.539
Emergent revascularization	2.06 (0.72,5.88)	.184	2.40 (0.85,7.36)	.118
Readmission due to heart failure	1.22 (0.18,8.57)	.902	1.06 (0.13,8.45)	.961
Overall	0.854 (0.447, 1.630)	.631	0.881 (0.457, 1.700)	.706

BMI = body mass index, CI = Confidential interval, HR = hazard ratio, hsCRP = high-sensitivity C-reactive protein.  
<sup>a</sup> HR adjusted by covariates of age, BMI, hypertension, and hsCRP.

However, previous long-term outcomes of STEMI patients receiving delayed PCI were rarely investigated. There is no specific definition or cutoff value of early and late PCI. Most studies chose approximately 2 weeks as the mark.<sup>[17,18]</sup> We divided the STEMI patients into the early group (3–14 days) and the late group (>14 days) since the median time of PCI to STEMI was about 14 days in this dataset. Since this study has a relatively small sample size; it is not good to divide the patients into 3 groups. Choosing the median time as the cutoff time point help to divide the patient more even. As a result, we decided to combine the early group (2–7 days) and medium group (8–14 days) into 1 early group (3–24 days). We found no statistical difference between the 2 groups in the primary endpoint (all-cause death) during the long-term follow-up.

Notably, the early group's incidence of recurrent MI was higher than the late group, and the risk was about 3 times higher. Song et al<sup>[18]</sup> reached a similar conclusion with us, and they found that the early group (3–15 days) showed a higher incidence of MI than the late group (15–30 days) during the 3-year follow-up. They found that the use of intra-aortic balloon pump in the early PCI group was significantly higher than that in the late PCI group, and severe CAD or complications such as slow blood flow during surgery existed in the early group. We hypothesized that the higher incidence might be associated with more severe coronary artery lesions and complications during PCI procedures in the early group. The coronary artery lesions of 2 groups were not recorded in this study. However, we found that the number of DES used of the early group was slightly higher than the late group with a *P* value of .108, which might reflect the more severe lesions. The underlying pathological reason could be that myocardial edema faded, and myocardial scarring began to form in the second week.<sup>[19]</sup> The higher incidence of recurrent MI in the early group requires further validation, including more retrospective data, randomized controlled trials, and translational studies.

This study had several limitations. First of all, this study is a retrospective observational cohort study with longitudinal data analyzed, leading to relatively higher bias and errors, even with PSM used, especially the selection bias. However, we must acknowledge that a real-world study could avoid the difficulties of randomized control trials and exhibit explicit situations. Second, compared with other studies, the small sample size could be the most prominent disadvantage.

## 5. Conclusions

In summary, early PCI (3–14 days) and late PCI (>14 days) using 2<sup>nd</sup> DES have similar efficacy and long-term outcomes. However, patients receiving early PCI are subjected to a relatively higher risk of recurrent MI.

## Author contributions

**Conceptualization:** Yu-Long Xue, Xue-Wen Li, Yu-Feng Li.

**Data curation:** Yue-Teng Ma, Yu-Ping Gao.

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