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Original Article

The application of a remote early intervention model for primary percutaneous coronary intervention in STEMI patients

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Abstract: Objective: Acute ST-segment elevation myocardial infarction (STEMI) usually occurs in people with coronary artery disease. Once the unstable atherosclerotic plaque ruptures, bleeding and intraluminal thrombus will occur. Methods: Fifty patients treated with emergency percutaneous coronary intervention (PCI) after a remote early intervention were selected as an observation group, and 50 patients treated with emergency PCI directly were selected as a control group. The two groups were analyzed retrospectively. The time from symptom onset to first medical contact (SO-to-FCM), the first medical contact to balloon dilatation (FMC-to-B) time, door to balloon (D-to-B) time, and the total ischemia time (TIT) of the patients in the two groups were recorded. Results: The SO-to-FMC, FMC-to-B, D-to-B, and TIT times in the observation group were significantly lower than those in the control group (all $P < 0.05$), and the standard-reaching rates of SO-FMC and D-to-B of the patients in the observation group were significantly higher than those in the control group (all $P < 0.05$). The time to peak of CK-MB and cTnI of the patients in the observation group was earlier and the peak value was lower (all $P < 0.05$). Conclusion: The remote early intervention model can significantly shorten the time of primary percutaneous coronary intervention in STEMI patients and improve prognosis, so it is worthy of clinical application.

Keywords: Acute ST-segment elevation myocardial infarction, remote early nursing intervention, percutaneous coronary intervention prognosis

Introduction

As a common cardiovascular emergency with high mortality, acute ST-segment elevation myocardial infarction (STEMI) usually occurs in people with coronary artery disease. Once the unstable atherosclerotic plaque ruptures, bleeding and intraluminal thrombus occurs, which completely blocks the culprit artery and interrupt or reduce the coronary blood supply rapidly, resulting in persistent and severe ischemia in the corresponding myocardial cells [1, 2]. An epidemiological survey in China showed that primary percutaneous coronary intervention (PPCI) is the best means for complete myocardial reperfusion in emergency STEMI patients, but it showed significant time dependence. For example, when the total ischemia time was prolonged by 30 minutes, the mortality risk of the patients is increased by 7.5% [3]. However, in reality, a large proportion of STEMI patients are not done with PPCI for vascular recanalization at the optimal time for various reasons, and their ischemic myocardium does not receive reperfusion in time, which seriously lowers the efficacy and prognosis [4]. Therefore, it is a problem for doctors to recanalize the coronary artery within 90 minutes after the onset to realize reperfusion therapy as soon as possible and maximize patient recovery. The European Society of Cardiology (ESC) and the American College of Cardiology Foundation/American Heart Association (ACCF/AHA) proposed to shorten the first medical contact to balloon dilatation (FMC-to-B) time in STEMI treatment guidelines in 2012 and 2013, respectively, including the whole pre-hospital and in-hospital first-aid stages. These proposals provided a new turning point for emergency work, and it is essential to establish an early

pre-hospital intervention model [5, 6]. The American Academy of Ambulatory Care Nursing (AAACN) defines remote nursing as "the health and nursing services provided through remote nursing methods such as telephone, fax, email, Internet, video in nursing practice to eliminate the limitations of time and space distance between nursing staff and service objects" [7]. This model has been widely applied in monitoring vital signs, body weight, blood glucose, fetal development in the uterus and hypoxia in patients, which greatly improves the treatment effect on diseases. The purpose of this study was to implement a remote early intervention model for STEMI patients. For the intervention, in addition to relevant medical interventions, the first-aid personnel should test patients with a 12-lead electrocardiogram (ECG) and test them in biochemical indexes when contacting the patients for the first time, transmit the results to relevant experts for consultation remotely and directly send the diagnosed patients to a catheterization room without emergency treatment for the treatment in a targeted first-aid manner, so as to improve the treatment reliability, efficacy and prognosis.

Materials and methods

General information

This study was approved by the Ethics Committee of The First Affiliated Hospital of Harbin Medical University. A total of 50 STEMI patients treated with emergency percutaneous coronary intervention (PCI) after remote early intervention in the First Affiliated Hospital of Harbin Medical University from January 2015 to January 2017 were selected as the observation group. The patients and their family members signed the informed consent. A total of 50 STEMI patients treated with emergency PCI directly in the First Affiliated Hospital of Harbin Medical University from January 2013 to January 2015 were selected as the control group. The two groups were analyzed retrospectively.

Inclusion criteria: (1) Patients whose ECG shows adjacent ≥ 2-lead ST-segment elevation ≥ 1 mv or elevation of myocardial injury markers; (2) patients whose time interval from onset to reperfusion was less than 12 h; (3) patient with continuous chest pain of more than 30 min that cannot be alleviated with sublingual drugs belonging to the nitrate ester group; (4) patients whose laboratory detection shows that the elevation of creatine kinase-MB (CK-MB) and cardiac troponin I (cTnI) is 5-25 times the upper limit of the normal reference value.

Exclusion criteria: (1) Patients without complete clinical data and without undergoing all detection criteria; (2) patients with other systemic body diseases; (3) patients who were previously diagnosed with complete left or right bundle branch block; (4) patients with a pacemaker; (5) patients who have recently used medicine affecting the observation of the ST-segment; (6) patients accompanied by PCI contraindications.

Methods

An ambulance was sent to a patient in the observation group for clinical reception after the patient called the first-aid center on the onset or the primary hospital where the patient was located in called for referral. After the ambulance arrived at the designated position, the patient was diagnosed with a 12-lead ECG and the ECG was transmitted to the cloud platform of the First Affiliated Hospital of Harbin Medical University in real time. Cardiovascular physicians evaluated the disease of the patient using a mobile phone, computer or other monitoring equipment, and performed emergency treatment and PCI preparation for the patient diagnosed with STEMI in the ambulance, including preparation and debugging of medical devices for emergency treatment such as ECG monitoring and nursing equipment and temporary pacing electrodes, preparation of tracheal intubation and oxygen supply for maintenance of normal breathing and pulse function of the patient and preparation of drugs for rescue, such as atropine (atropine for conventional subcutaneous injection, 0.5-3 mg/d, Anhui BBCA Pharmaceuticals Co., Ltd.) and epinephrine (adrenaline hydrochloride injection, 0.25-1 mg/d, Dandong Yichuang Pharmaceutical Co., Ltd.). The patient was given Bayer aspirin enteric-coated tablets (loading dose: 150-300 mg, Bayer HealthCare Co., Ltd.) and clopidogrel hydrogen sulphate tablets (loading dose: 300-600 mg; for those > 75 years old, loading dose: 75 mg; Sanofi Pharmaceutical Co., Ltd.) for anticoagulation and coronary thrombotic occlusion alleviation of symptoms of the patient undergoing PCI surgery. In addition, family members of the patient were acquainted with the informed consent form and possible abnormal conditions during surgery. After the family members

signed the informed consent, the hospital was notified to prepare the catheterization room for PCI surgery directly after the ambulance arrived. The control group did not perform ECG monitoring in the pre-hospital stage, ECG acquisition and determination of biochemical indexes were conducted quickly to the control group after the doctor visit. The family members of the patients were acquainted with the informed consent form after the diagnosis, and then the catheterization room was prepared for PCI surgery immediately after the consent was obtained.

Outcome measures

Material collection: Relevant case information was collected based on the admission diagnosis and medical history surveys of the patients, including gender, age, body mass index (BMI), disease history (hypertension, hyperglycemia, hyperlipidemia and heart disease).

Main indexes: FMC (First medical contact refers to the time point when first-aid personnel arrive at the scene of the incident). The time from symptom onset to first medical contact (SO-to-FMC) [8], the time from the first medical contact to balloon dilatation (FMC-to-B) [9], door-to-balloon (D2B) time [10] and total ischemia time (TIT) of the patients in the two groups were recorded [11].

SO-to-FMC standard-reaching rate: SO-to-FMC < 120 min [8]; D-to-B standard-reaching rate: D-to-B < 90 min [10]. The mortality rate within 30 days after the onset and the incidence of major adverse cardiovascular and cerebrovascular events (MACCE) within 1 year after surgery were calculated, which mainly included cardiac death, nonfatal myocardial infarction, target vessel revascularization, stroke, and so on [12].

Secondary indexes: Hypertension: The systolic blood pressure was tested for 3 consecutive days, once a day. Patients with a mean value of systolic blood pressures over the three times ≥ 140 mmHg and/or a mean value of diastolic blood pressures over the three times ≥ 90 mmHg or with a history of hypertension were determined as hypertensive patients [13].

Diabetes: Patients with diabetes showed clinical manifestations including overeating, overdrinking, polyuria, mean blood glucose values of all the 3 random sampling tests ≥ 11.1 mmol/L and mean fasting blood glucose in the morning of all the 3 random sampling tests ≥ 7.0 mmol/L [14].

Hyperlipidemia: High cholesterol: blood total cholesterol (TC) ≥ 6.22 mmol/L. High triglyceride: blood triglyceride (TG) ≥ 2.26 mmol/L. Low high-density lipoprotein: blood high-density lipoprotein cholesterol (HDL-C) < 0.91 mmol/L. Low-density lipoprotein: blood low-density lipoprotein cholesterol (LDL-C) ≥ 4.14 mmol/L. Patients with one or more of the above abnormal lipid indicators were patients with hyperlipidemia [15].

The patients were tested in CK-MB and cTnI every 2 hours through enzyme colorimetry with an Olympus biochemical analyzer (Olympus Optical Co., Ltd., Model: Au400) after admission to hospital, and the time to peak and peak value of them, pro-B-type natriuretic peptide (NT-ProBNP), high sensitive C-reactive protein (hs-CRP) values at 0.5 h, 24 h, 72 h, 7 d and 30 d after surgery were counted.

Statistical methods

The software SPSS21.0 was adopted for the statistical analysis. The measurement data were expressed as the means ± standard deviation ($\bar{x}$ ± sd). The measurement data of the two groups conforming to a normal distribution were processed with a *t*-test, and those not conforming to a normal distribution were processed with a rank sum test. The enumeration data were expressed in case number/percentage (n/%) and processed with a chi-square test and the Fisher exact probability method. Multiple logistic regression analysis was performed by taking the occurrence of MACCE as a dependent variable and the occurrence of coronary heart disease, hyperlipidemia, SO-FMC (> 120 min), D-to-B (> 90 min) and age > 70 years old as independent variables. P < 0.05 is considered statistically significant.

Results

Comparison of general information

There was no difference in gender proportion, age, BMI, or the proportion of patients with hypertension, hyperlipidemia, and diabetes between the two groups (all P > 0.05). See **Table 1**.

Table 1. Comparison of general information ($\bar{x}$ ± sd)

Group	Control group (n = 50)	Observation group (n = 50)	t/χ^2	P
Gender (male/female)	24/26	27/23	0.360	0.548
Age (years old)	65.56 ± 5.12	64.55 ± 6.98	0.778	0.439
BMI (kg/m^2)	22.57 ± 3.18	23.69 ± 3.63	1.597	0.114
Hypertension (n, %)	8 (16.00)	10 (20.00)	0.271	0.603
Hyperlipidemia (n, %)	16 (32.00)	13 (26.00)	0.437	0.509
Diabetes (n, %)	10 (20.00)	15 (30.00)	1.333	0.248

Note: BMI, body mass index.

Table 2. Comparison of treatment time between the two groups ($\bar{x}$ ± sd)

Group	Control group (n = 50)	Observation group (n = 50)	t/χ^2	P
SO-to-FMC (min)	176.89 ± 55.96	133.87 ± 37.31	4.384	< 0.001
FMC-to-B (min)	134.35 ± 40.21	113.32 ± 23.14	3.108	0.003
D-to-B (min)	104.41 ± 27.39	72.47 ± 22.85	6.268	< 0.001
TIT (min)	382.01 ± 57.16	263.01 ± 57.16	9.905	< 0.001
FMC-to-B standard-reaching rate	40 (80.00%)	25 (50.00%)	9.890	0.002
D-to-B standard-reaching rate	38 (76.00%)	23 (46.00%)	9.458	0.002

Note: SO-to-FMC, symptom onset to the first medical contact; FMC-to-B, first medical contact to balloon dilatation; D-to-B, door to balloon; TIT, total ischemia time.

Comparison of treatment time between the two groups

The SO-to-FMC, FMC-to-B, D-to-B and TIT times of the patients in the observation group were significantly lower than those in the control group (all P < 0.05). See **Table 2** and **Figure 1**. The patients in the observation group showed significantly higher SO-FMC (80.00% vs. 50.00%, χ^2 = 9.890, P = 0.002) and D-to-B standard-reaching rate (76.00% vs. 46.00%, χ^2 = 9.458, P = 0.002) than patients in the control group, which were statistically significant (both P < 0.05).

Comparison of biochemical indexes between the two groups

The changing curves of CK-MB and cTnI of the patients in the observation group were consistent, but the time to peak of CK-MB and cTnI was earlier and the peak value was lower, which were statistically significant (both P < 0.05). See **Figure 2** and **Table 3**. The patients in the observation group showed no difference with the control group in hs-CRP (P > 0.05) and significantly lower the expression level of NT-ProBNP than the control group (P < 0.05). See **Figure 3**.

Comparison of prognosis between the two groups

The incidence of no MACCE in the observation group was significantly higher than it was in the control group within 30 days after onset, which was statistically significant (P < 0.05). See **Figure 4A**. However, there was no difference in mortality for MACCE between the observation group and the control group within 1 year after onset (P > 0.05). See **Figure 4B**.

Multiple logistic regression analysis of the occurrence of MACE

The multiple logistic regression analysis was performed by taking the occurrence of MACCE as a dependent variable and the occurrence of coronary heart disease, hyperlipidemia, SO-to-FMC (> 120 min), D-to-B (> 90 min), and age > 70 years old as independent variables. At α = 0.05, the results showed that all the factors mentioned above could be included in the independent variables of the regression equation as risk factors of MACCE occurrence. See **Table 4**.

Discussion

In recent years, with an increase in the intake of lipid materials and the influence of bad habits, the risk factors of cardiovascular diseases have increased, leading to an increase in morbidity, seriously affecting the quality of life of patients and increasing the medical burden, which has become a major public health problem [16]. Epidemiological results show that there are nearly 300 million patients with cardiovascular diseases in China, and the incidence of STEMI is more than 10% [17]. Even though the treatment methods for STEMI have significantly developed and processed, early PCI and intravenous thrombolysis for myocar-

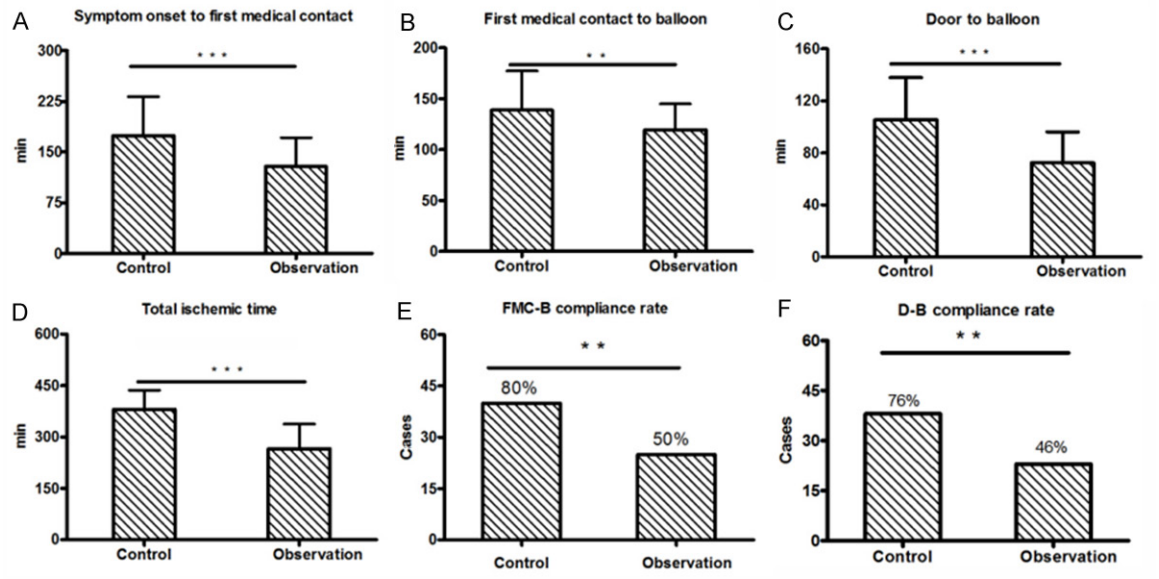

Figure 1. Comparison of treatment time between the two groups. $^{**}P < 0.01$, $^{***}P < 0.001$; FMC-to-B, first medical contact to balloon dilatation; D-to-B, door to balloon. A: The time from symptom onset to first medical contact; B: The time from the first medical contact to balloon dilation; C: Door to balloon time; D: The total ischemic time. The longer the above time was, the greater the chance of death and MACCE was; E: FMC-to-B standard-reaching rate; F: D-to-B standard-reaching rate.

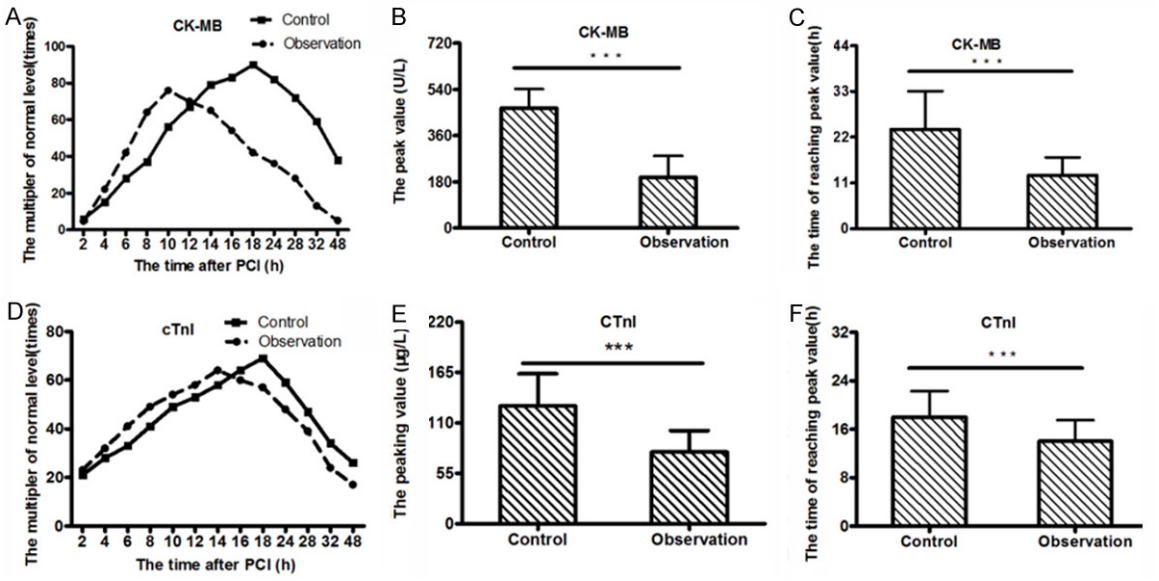

Figure 2. Comparison of CK-MB and cTnI changing curves, peak value and peak time ($\bar{x} \pm sd$). $^{***}P < 0.001$; CK-MB, creatine kinase-MB; cTnI, cardiac tropnin I. A: Changing curve of CK-MB, which can reflect the change of thrombolysis of patients; B: Peak value of CK-MB. The higher the peak value was, the larger the infarct size was; C: Time to peak of CK-MB. The shorter the time was, the higher the probability of recanalization was; D: Changing curve of cTnI, which can reflect the postoperative effect on patients in real time; E: cTnI peak value. The higher the peak value was, the larger the infarct size was; F: Time to peak of cTnI. The shorter the time was, the better the recanalization effect was.

dial reperfusion remain the core concepts in its treatment [17, 18]. The recommendations for shortening the D-to-B time proposed by early European and American guidelines were not

Table 3. Comparison of biochemical indexes between the two groups ($\bar{x} \pm sd$)

Group	Control group (n = 50)	Observation group (n = 50)	t/χ^2	P
CK-MB peak value (U/L)	455.14 ± 77.02	198.53 ± 86.87	15.471	< 0.001
CK-MB time to peak (h)	23.85 ± 9.27	12.82 ± 4.28	7.563	< 0.001
cTnI peak value (μg/L)	128.81 ± 32.99	78.14 ± 24.09	8.682	< 0.001
cTnI time to peak (h)	18.48 ± 4.57	14.69 ± 3.61	5.743	< 0.001

Note: CK-MB, creatine kinase-MB; cTnI, cardiac troponin I.

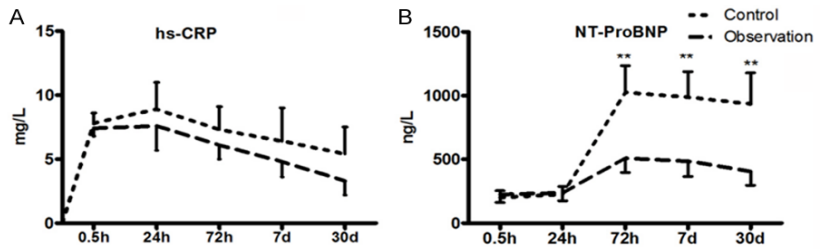

Figure 3. Change of hs-CRP and NT-ProBNP expression levels. **P < 0.01; hs-CRP, high sensitive C-reactive protein; NT-ProBNP, pro-B-type natriuretic peptide. A: Changing curve of hs-CRP over time after surgery. It can effectively reflect the cardiovascular inflammatory of patients; B: NT-ProBNP of patients after surgery. It can effectively reflect patients' myocardial injuries.

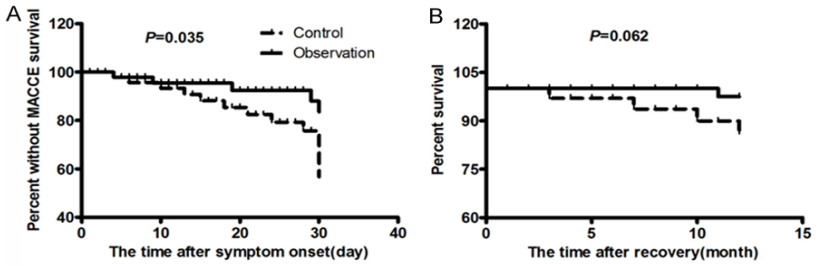

Figure 4. Comparison of prognosis between the two groups. MACCE, major adverse cardiovascular and cerebrovascular events. A: Survival rate without MACCE. The higher the survival rate was, the better the patient recovered. B: Survival rate. The higher the rate was, the higher the postoperative survival rate of the patients was.

perfect, because they only covered the in-hospital treatment time, but the most critical treatment for STEMI is the total ischemic time from onset to reperfusion. For STEMI patients, an early coronary blood supply is particularly important. When lesion vessels are completely occluded for more than 20 minutes, myocardial cells begin to show apoptosis and necrosis, followed by STEMI pathological changes [19]. When the time exceeds 1-2 h, the majority of cells show apoptosis and necrosis, and myocardial interstitial hyperemia, edema, and infiltration of a large number of inflammatory cells occur. Therefore, time is particularly important for myocardial ischemia in STEMI patients [20]. Reperfusion time is an independent risk factor for the prognosis of STEMI patients. Cardiovascular guidelines in many countries recommend that the door to balloon time must be less than 90 min. However, at present, many hospitals in China do not reach the standard [7]. Therefore, how to shorten the door to balloon time has become a hot topic of research.

The results of this study showed that the SO-to-FMC, FMC-to-B, D-to-B and TIT time of patients in the observation group were significantly lower than those in the control group, and the SO-FMC (80.00% vs. 50.00%) and D2B (76.00% vs. 46.00%) standard-reaching rates of patients in the observation group were significantly higher than those in the control group, which were statistically significant. The main reasons were as follows: for patients undergoing remote early intervention, in addition to relevant medical interventions, first-aid personnel should also record the SO-to-FMC time of the patients in detail and contact hospital experts in time after arriving at the scene, and contact a catheterization room as soon as possible for direct PCI emergency surgery for patients diagnosed with STEMI in the ambulance before admission to the hospital, and obtain informed consent form signatures. This process can directly affect D-to-B time and even the total ischemia time, which can be improved to increase the chance of survival.

CK-MB and cTnI are specific markers of myocardial necrosis, and their peak values can effectively reflect the degree of myocardial necrosis

Table 4. Multiple logistic regression analysis of the occurrence of MACCE

Indicators	B	SE	Wald	OR	95% CI	P
History of coronary heart disease	1.847	0.907	4.145	6.342	1.071-35.542	0.042
Hyperlipidemia	2.774	0.937	8.773	16.024	2.556-100.459	0.003
SO-to-FMC (> 120 min)	2.805	0.960	8.548	16.533	2.521-108.421	0.003
D-to-B (> 90 min)	2.203	0.932	5.585	9.053	1.456-56.276	0.018
Age (> 70 years old)	1.920	0.944	4.135	6.821	1.072-43.406	0.042

Note: MACCE, major adverse cardiovascular and cerebrovascular events; SO-to-FMC, symptom onset to the first medical contact; D-to-B, door to balloon; SE, standard error; Wald, wald test; OR, odd ratio; CI, confidence interval.

[21]. In this study, the changing curves of CK-MB and cTnI of patients in the observation group were consistent, but the time to peak of CK-MB and cTnI was earlier and the peak values of them were lower, which were statistically significant. It was suggested that patients in the control group had more severe myocardial necrosis and increased risk of poor microcirc ulation perfusion. The hs-CRP of the patients in the observation group- was not different from the control group after sugery. NT-ProBNP was adopted as an index to evaluate the sensitivity and specificity of cardiac function, and its expression level in the observation group was significantly lower than it was in the control group at the same time, indicating that the patients in the observation group showed better recovery of cardiacfunction and a reduced risk of heart failure [22]. The survival rate of patients without MACCE in the observation group was significantly higher than it was in the control group within 30 days after onset, which was statistically significant. However, the mortality rate of patients in the observation group was not different from the rate in the control group within 1 year after onset. It was consistent with the results reported by other researchers that D-to-B < 90 min does not improve patient survival during hospitalization, but patients treated with PCI at the first visit have a significantly lower incidence of MACCE events [23]. The main factor influencing the prognosis is the reperfusion treatment time. Complete revascularization and reduction of the occurrence of serious complications are necessary for prognosis improvement. D-to-B < 90 min and FMC-to-B < 120 min are still the key factors for the prognosis of emergency PCI. Moreover, patients with coronary heart disease and hyperlipidemia, SO-to-FMC (> 120 min), D-to-B (> 90 min) and age > 70 years old are more likely to have MACCE, so more attention should be paid to them in clinical treatment.

However, the number of patients involved in this research was relatively small, and the alarm time range of patients with chest pain symptoms was large, which may affect the accuracy of the results. In addition, the survival conditions of the patients after discharge was only followed up by telephone, so relevant biochemical index data about disease change were not obtained. Therefore, the study results still need further improvement and confirmation. The study showed that the treatment time delay was closely related to the inability of patients to correctly judge the discomfort symptoms, and hesitation in signing the informed consent form. Then, our task is to popularize awareness of the disease through mainstream media, Internet, social software and mobile APP among people, and acquaint them with the risk of diagnosis and treatment of the disease, so as to shorten the SO-to-FMC time and the time of signing the informed consent form. In addition, another focus is to coordinate the dispatch of the first-aid center and various departments of hospitals and transmit the most accurate and complete real-time data to experts through remote intelligent terminal equipment, so as to st-rive for the most scientific and reasonable treatments for patients in the shortest time.

In conclusion, the remote early intervention model can shorten the treatment time of primary percutaneous coronary surgery and improve the prognosis of patients. However, how to further shorten the D-to-B and FMC-to-B times is still the primary task of STEMI treatment in China.

Disclosure of conflict of interest

None.

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