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ORIGINAL RESEARCH

Investigating the efficacy of pre-hospital and in-hospital collaborative treatment platform connected with 120-ambulance in the treatment of patients with acute myocardial infarction

Mingqiang Gao[1], Jie Shen[1,*], Weichun Mo[1,*]

[1]Center of Emergency & Intensive Care Unit, Jinshan Hospital, Fudan University, 201508 Shanghai, China

***Correspondence**
assertive@zohomail.cn
(Jie Shen);
mwc_dr55@163.com
(Weichun Mo)

Abstract

This study aimed to examine the effectiveness of an integrated pre-hospital and in-hospital collaborative treatment platform connected with 120-ambulance in treating patients with acute myocardial infarction (AMI). 114 patients with AMI who were treated at our hospital within one year of the collaborative treatment model's implementation were selected as the observation group (January 2022 to December 2022). A random selection of 114 cases treated using the conventional model from January 2020 to December 2020 was chosen as the control group. Control patients received conventional treatment, while observation patients received an integrated pre-hospital and in-hospital treatment. Comparisons of effects were made between the two treatment models for AMI patients. The observation group showed significantly lower first medical contact (FMC) to balloon dilation (FMC-to-B), door-to-balloon (D-to-B), and chest pain onset to admission times than the control group. Across both groups, 99.12% of pre-hospital electrocardiography (ECGs) were completed (113/114), and a significantly higher proportion of patients with Killip class ≥II at immediate admission was observed in the observation group ($p < 0.05$). Observation group showed significantly higher Left Ventricular End-Systolic Volume (LVESV) and Left Ventricular End-Diastolic Volume (LVEDV) than control group ($p < 0.05$) one month after surgery. The 6-minute walking distance (6MWD) of the observation group was significantly longer than the control group, and the time taken for the 10-meter walking test was significantly shorter ($p < 0.05$). A significantly lower incidence rate of hospitalization complications occurred in the observation group ($p < 0.05$). The integrated pre-hospital and in-hospital treatment platform connected with 120-ambulance showed beneficial outcomes for AMI patients, significantly reducing treatment delay, improving postoperative cardiac function, and reducing postoperative complications, making it worthwhile for promotion in AMI clinical treatment.

Keywords

Integrated pre-hospital and in-hospital treatment model; 120-ambulance; Acute myocardial infarction

1. Introduction

Acute myocardial infarction (AMI) is a prevalent cardiovascular emergency that results from acute and prolonged ischemia and hypoxia in the coronary arteries, leading to myocardial necrosis. AMI is clinically characterized by prolonged chest pain, elevated serum myocardial enzyme levels, and progressive electrocardiographic alterations. As a consequence, patients are at risk of severe complications, arrhythmias, heart failure and shock [1, 2]. AMI is associated with high mortality rate, exceeding other cardiovascular conditions, with most deaths occurring outside of hospitals [3]. Medical attention is often delayed in China. Reports indicate that the time between AMI onset and the first medical encounter frequently exceeds 12 hours. Reperfusion therapy is only administered to about half of patients upon admission to the hospital [4]. The condition is acutely life-threatening, with more than 40% of patients' mortalities within the first hour of symptom onset. In AMI, treatable fatal arrhythmias contribute greatly to pre-hospital sudden deaths, suggesting the critical importance for timely therapeutic intervention [5, 6]. Pre-hospital care capabilities, communication between emergency medical services (EMS) and hospitals, sequential treatment procedures, and overall efficiency have been severely undermined by "120" ambulance services [7]. An emerging discipline, pre-hospital emergency care provides medical assistance before hospitalization, continuous monitoring and transportation management. The integration of pre-hospital and in-hospital treatment frameworks can expedite the collection of patient histories, condition assessments, and clinical data, including blood tests and medical imaging. AMI patients can exchange real-time information between pre-hospital and in-hospital settings, receive remote consultations, and transition seamlessly from EMS to hospital care. Integrated care is aimed at providing rapid, effective and comprehensive care system for AMI [8]. Despite its potential benefits, research on integrated pre-hospital and in-hospital treatment models in China remains scarce. This study examines the effectiveness of a collaborative treatment platform that aligns pre-hospital emergency interventions with in-hospital care, connected *via* EMS 120 ambulance, in managing AMI patients.

2. Materials and methods

2.1 General information

114 patients with acute myocardial infarction who were treated at our hospital within one year of the collaborative treatment model's implementation were selected as the observation group (January 2022 to December 2022). A random selection of 114 cases treated using the conventional model from January 2020 to December 2020 was chosen as the control group. Table 1 presents general information for both groups with comparable data ($p > 0.05$).

TABLE 1. Comparison of general data of both groups ($\bar{x} \pm s$).

Group	n	Age (yr)	Gender (male/female)
Observation group	114	59.30 ± 20.46	57/57
Control group	114	59.45 ± 21.36	57/57
χ^2/t	-	0.0541	0.000
p	-	0.958	1.000

Inclusion criteria: (1) Complying with AMI diagnostic criteria. (2) Conscious and cooperative during basic examinations. (3) Complete clinical data ischemic chest pain history. (4) Informed consent signed.

Exclusion criteria: (1) Malignant tumors or autoimmune diseases. (2) Accompanied by other heart diseases, such as myocarditis. (3) Dysfunction of major organs, such as the liver and kidneys. (4) Severe mental disorders.

2.2 Methods

Control group received conventional treatment protocols. In response to a "120" emergency call, an ambulance was dispatched to the patient's location, where a doctor performed pre-hospital electrocardiography (ECG) in the ambulance. An emergency department (ED) was notified *via* telephone in cases deemed critical before the patient arrived. After admission to the ED, patients were examined and diagnosed. AMI suspects were referred to the cardiology unit. As per consultation, antiplatelet therapy was initiated, and percutaneous coronary intervention (PCI) was considered.

The observation group was given a collaborative pre-hospital and in-hospital care model, which included: (1) Pre-Hospital Emergency Care A dispatch center dispatches an ambulance and notifies the hospital's emergency portal simultaneously when individuals reporting chest pain or suspected coronary artery disease call "120". The ambulance was equipped with ECG devices (12D, Shenzhen Airuikang Medical Equipment Co. Ltd, Shenzhen, China), cardiac monitors equipment (HD 12, Dawei Medical (Jiangsu) Co. Ltd, Xuzhou, China), defibrillators/pacemakers (Reanibex 700, Jiangsu Rixin Medical Equipment Company, Zhangjiagang, China), oxygen supply machine (ZD-20LB, Xinda Medical Equipment Co. Ltd, Rizhao, China), and a range of medications for anticoagulation, platelet inhibition and ischemia alleviation. An ECG with 12 or 18 leads was initially performed to diagnose AMI remotely. The chest pain was ruled out in spite of pulmonary embolism or aortic dissection being considered non-cardiac causes. Patients were instructed to take 300 mg of aspirin enteric-coated tablets (J20171021, Bayer Healthcare GmbH, Leverkusen, Germany) and clopidogrel (H20233888, Hubei Sihai Pharmaceutical Co. Ltd. Wuhan, China), followed by intravenous nitroglycerin, optional antihypertensive agents, and supplemental oxygen. ECG and cardiac monitoring readings guided ED physicians in identifying malignant arrhythmias and performing remote defibrillation when necessary. Concurrently, risk stratification was performed, priming ED and catheterization room teams for high-risk patients indicated for PCI, ensuring expedited access to spaces and staff for prompt coronary artery reperfusion. (2) In-Hospital Emergency Care: ED clinicians and cardiologists worked together during initial stabilization. On admission to the hospital, patients were administered oxygen, fitted with cardiac monitors, had vital signs recorded, intravenous (IV) drips titrated, and blood samples taken for enzymes indicative of cardiac injury. We performed bedside echocardiograms, managed arrhythmias and heart failure, and reassessed high-risk individuals. Cardiopulmonary resuscitation (CPR) and pacing/defibrillation interventions were applied to cardiac arrest cases. Thrombolysis success rates were assessed, and rapid coordination for PCI referral and transfer was executed for suitable patients.

2.3 Observational indices

(1) Clinical indicators: Time from first medical contact (FMC) to balloon dilation (FMC-to-B), door-to-balloon (D-to-B) time, chest pain onset to admission time, pre-hospital ECG completion rate, and the proportion of patients with Killip class ≥II at immediate admission. (2) Cardiac function: Comparing Left Ventricular End-Systolic Volume (LVESV) and Left Ventricular End-Diastolic Volume (LVEDV) before and one month after PCI between both groups. (3) Walking ability: (a) A 6-minute walking test. On a flat surface, 30 meters are marked with spheres placed at each end to represent the start and finish lines. Six-minute walking distances (6MWD) are recorded by instructing patients to walk back and forth at a steady,

faster pace. (b) A 10-meter walking test: Indoors, patients walk a straight line of 12 meters at a fast and steady pace. A time was recorded, measured three times, and averaged for walking 10 meters. (4) Hospitalization Complications: Recurrent myocardial infarction during the hospitalization, in-hospital mortality rates, and cardiogenic shock cases were documented.

2.4 Statistical methods

Data analysis was performed using SPSS 22.0 (IBM, Armonk, NY, USA). Quantitative data were presented as mean and standard deviation, and compared by the *t*-test. Categorical data were presented as percentages (%) and compared using the χ^2 test. $p < 0.05$ indicates statistically significant differences.

3. Results

3.1 Clinical indicators

The observation group showed significantly shorter times from first medical contact (FMC) to balloon dilation (FMC-to-B), door-to-balloon (D-to-B), and from onset of chest pain to hospital admission ($p < 0.05$). Across both groups, 99.12% of pre-hospital ECGs were completed (113/114), and a significantly higher proportion of patients with Killip class ≥II at immediate admission was observed in the observation group ($p < 0.05$) (Table 2).

3.2 Cardiac function

Observation group showed significantly higher Left Ventricular End-Systolic Volume (LVESV) and Left Ventricular End-Diastolic Volume (LVEDV) than control group one month after surgery ($p < 0.05$) (Table 3).

3.3 Walking ability

The observation group walked a significantly longer distance in the 6-minute walking test and took less time to complete the 10-meter walking test than the control group ($p < 0.05$) (Table 4).

3.4 Hospitalization complications

A significantly lower incidence rate of hospitalization complications occurred in the observation group ($p < 0.05$) (Table 5).

4. Discussion

Acute myocardial infarction (AMI) coronary arteries are suddenly blocked, resulting in ischemic necrosis of the heart muscle and subsequent impairment of cardiac function. AMI is known for its severe and life-threatening manifestations of acute coronary syndrome, including atherosclerosis, reduced myocardial blood flow and oxygenation, and heightened oxygen demand [9]. AMI events may be precipitated by a history of heart disease, smoking, alcohol abuse, hypertension, diabetes, obesity, irregular lifestyles, emotional stress and climatic variations [10]. China's cardiovascular diseases are on the rise, and AMI is a major contributor. Limiting myocardial injury and enhancing survival rates require swift revascularization of occluded coronary. Thus, prompt AMI intervention is crucial to patient survival and prognosis.

Pre-hospital delay is predicted by profuse sweating, age, admission route and non-statim (ST) elevation myocardial infarction (NSTEMI). Admissions *via* non-120 emergency services are 3.571 times delayed compared to 120 admissions [11]. The 120-ambulance service is often used by patients only when they perceive an immediate life-threatening situation due to traditional beliefs and economic factors, which diminishes its apparent advantages for pre-hospital care [12]. Therefore, pre-hospital protocols, actions and systems profoundly influence AMI patient outcomes. For successful resuscitation and patient prognosis, pre-hospital emergency care quality and efficiency are crucial. In this study, the observation group had significantly lower FMC-to-B, D-to-B, and chest pain onset to admission times than the control group ($p < 0.05$). Across both groups, 99.12% of pre-hospital ECGs were completed (113/114), and a significantly higher proportion of Killip class II patients upon immediate admission was observed in the observation group ($p < 0.05$). Results suggest that an integrated pre-hospital and in-hospital approach to managing AMI patients minimizes delays. By integrating vehicle-mounted information terminals with the hospital reception system, the collaborative platform enhances the existing 120 emergency system, enabling vital patient data to be transmitted promptly to the ED or chest pain center before ambulance arrival. Through streamlined communication, medical staff are constantly aware of the situation and prepared for the incoming patient, fostering uninterrupted emergency information coordination. Moreover, the treatment platform employs standardized time management, with critical timestamps automatically recorded [13, 14]. Automated recording eliminates subjectivity associated with manual entry of relevant timings, such as symptom onset, alarm activation and time of initial electrocardiogram (ECG). Platform time measurements are synchronized with the database server's time server. A consistent time signal is provided to all connected system nodes, ensuring synchronization with the database server and establishing a uniform time standard across the treatment platform [15]. Additionally, the platform features statistical analysis capabilities for data, organized by etiology, diagnostic categories and various temporal milestones, including intervals from symptom onset to critical diagnostic and therapeutic procedures. It reduces emergency response times and improves treatment outcomes. In Yekefallah L's study, treatment delays were decreased with an integrated model of pre-hospital and in-hospital emergency care. Pre-hospital emergency staff swiftly obtain ECGs, diagnose ST-elevation myocardial infarction (STEMI), and transfers patients directly to the catheterization lab, thereby reducing door-to-balloon times significantly [16]. Observation group showed significantly higher Left Ventricular End-Systolic Volume (LVESV) and Left Ventricular End-Diastolic Volume (LVEDV) than control group ($p < 0.05$) at one month after surgery. A superior performance was also achieved by the observation group in the 6-minute walking test and faster completion of the 10-meter walking ($p < 0.05$). This suggest that the integrated pre-hospital and in-hospital treatment model improves cardiac

TABLE 2. Comparison of clinical indicators between both groups ($\bar{x} \pm s$).

Group	n	FMC-to-B (min)	D-to-B (min)	Time from onset of chest pain to admission (min)	Completion rate of pre hospital electrocardiogram	The proportion of patients with Killip ≥Level II
Observation group	114	116.82 ± 35.49	90.64 ± 35.08	107.50 ± 14.58	113 (99.12)	110 (96.49)
Control group	114	139.67 ± 49.88	122.37 ± 47.48	204.30 ± 23.29	113 (99.12)	100 (87.72)
χ^2/t	-	3.985	5.739	37.614	0.504	6.032
p	-	<0.001	<0.001	<0.001	0.478	0.015

FMC-to-B: first medical contact to balloon dilation; D-to-B: door-to-balloon.

TABLE 3. Comparison of cardiac function between both groups ($\bar{x} \pm s$).

Group	n	LVESV (mL)		LVEDV (mL)	
		Before surgery	One month after surgery	One month after surgery	One month after surgery
Observation group	114	56.30 ± 5.27	66.37 ± 7.28	111.54 ± 8.47	129.83 ± 9.51
Control group	114	55.67 ± 5.62	58.61 ± 6.00	112.51 ± 8.43	114.10 ± 7.94
t	-	0.873	8.783	0.867	13.557
p	-	0.384	<0.001	0.387	<0.001

LVESV: Left Ventricular End-Systolic Volume; LVEDV: Left Ventricular End-Diastolic Volume.

TABLE 4. Comparison of walking ability of both groups ($\bar{x} \pm s$).

Group	n	6MWD (m)	10 m walking test (s)
Observation group	114	327.95 ± 68.65	9.48 ± 1.84
Control group	114	283.35 ± 41.87	11.75 ± 2.74
t	-	5.922	7.344
p	-	<0.001	<0.001

6MWD: 6-minute walking distance.

TABLE 5. Comparison of hospitalization complications of both groups (n (%)).

Group	n	Recurrent myocardial infarction	Case fatality rate	Hospital induced shock	Total
Observation group	114	0 (0.00)	1 (0.88)	1 (0.88)	2 (1.75)
Control group	114	2 (1.75)	6 (5.26)	3 (2.63)	11 (9.65)
χ^2					6.608
p					0.010

function in AMI patients, yielding substantial clinical benefits. In response to a 120-emergency call, this integrated model dispatches ambulances with specialized medical personnel equipped for in-transit medical emergencies. Such prompt intervention can significantly decrease myocardial reperfusion time, rescue more cardiac tissue, notably improve outcomes, and manage complications related to myocardial infarction during transportation. PeiZe T's research emphasizes the importance of a well-structured pre-hospital emergency medical network and resource allocation. By combining these measures with strengthened connections between pre-hospital and hospital emergency services and standardized pre-hospital resuscitation practices, patients with chest pain can experience shorter emergency responses and shorter ischemic times, thus improving their prognosis [17]. Moreover, emergency physicians and cardiologists collaborate on resuscitation efforts before admission to the hospital. Upon arrival, patients are promptly provided with oxygen therapy, vital sign monitoring, cardiac surveillance, intravenous access, laboratory blood draws, and treatments for arrhythmias and heart failure, along with rapid assessment and intervention for high-risk patients [18, 19]. These steps enhance the potential for positive patient outcomes, as shown by improved cardiac function in the observation group compared to the control group one month after percutaneous coronary intervention (PCI). Additionally, a significantly lower incidence rate of hospitalization complications occurred in the observation group ($p < 0.05$). Integrated approaches not only shorten treatment timelines but also reduce the risk of serious complications such as malignant arrhythmias, heart failure and cardiogenic shock, thereby enhancing patient care efficiency. The "Integrated Pre-Hospital and In-Hospital Treatment Platform" operates over local area networks, specialized networks, the internet, and fifth-generation (5G) wireless technology. It connects the ED, patients, the 120-command center, and ambulance services. It transmits vital signs, live ambulance video feeds, cardiac monitor readings, and ambulance location directly to the hospital [20, 21]. A facility is notified prior to a patient being admitted for hospitalization so that necessary reception and treatment arrangements can be made. By providing remote guidance *via* video connection, in-hospital experts can optimize patient survival chances and enhance critical case management capabilities in critical cases. Through the use of networked information to streamline the transition between pre-hospital and in-hospital care, the platform has access to superior hospital resources, advancing information exchange, diagnosis and treatment processes. This dramatically improves resuscitation success rates and reduces postoperative complications. According to Bettencourt Nuno's research, in heart failure and other complications have significantly decreased after one year, in agreement with this study [22]. Considering this study's small sample size, biased results are possible. Future research with expanded sample sizes and multicenter collaboration has the potential to increase the validity and generalizability of the findings.

5. Conclusions

In summary, the implementation of an integrated pre-hospital and in-hospital treatment platform connected with 120-ambulance, showed beneficial outcomes for AMI patients. The effectiveness of this approach has been demonstrated in significantly improving postoperative cardiac function metrics and reducing postoperative complications. Consequently, it deserves consideration for wider implementation across different regions as a noteworthy model for AMI management.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

MQG—designed the study and carried them out, prepared the manuscript for publication and reviewed the draft of the manuscript. MQG, JS, CWM—supervised the data collection, analyzed the data, interpreted the data. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of Jinshan Hospital, Fudan University (Approval no. 2022-S22-01). Written informed consent was obtained from a legally authorized representative for anonymized patient information to be published in this article.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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