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Article

Influencing Factors and Survival Analysis of Late Readmission after Percutaneous Coronary Intervention in Patients with Acute Myocardial Infarction

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Abstract

Objective: This study aimed to explore the influencing factors analysis of late readmission after patients with acute myocardial infarction received percutaneous coronary intervention (PCI). **Methods**: A total of 368 patients with acute myocardial infarction who received PCI treatment in West China Hospital, Sichuan University/West China School of Nursing, Sichuan University from January 2018, to January 2021, were selected for the study. Among them, 110 subjects were excluded, and 258 subjects were finally included, of which 124 were readmitted and 134 were not readmitted. The baseline data and clinical characteristics of the patients were collected, and the influencing factors of readmission were analyzed by logistic regression analysis. The readmitted patients were followed up for 12 months. The Kaplan–Meier method was used to analyze the survival of patients with delayed readmitted and calculate the survival rate. **Results**: Significant differences were found between readmitted patients and non-readmitted patients in terms of age, chronic obstructive pulmonary disease (COPD), history of early coronary heart disease, history of hypertension, history of oral anticoagulant drugs, and left ventricle ejection fraction (LVEF, $p < 0.05$). No significant differences were observed in gender, body mass index, family history of acute myocardial infarction, history of chronic kidney disease, history of diabetes, history of smoking, history of drinking, and the number of implanted stents and diseased vessels ($p > 0.05$). Binary logistic regression analysis showed that age, COPD, history of premature coronary heart disease, history of oral anticoagulant drugs, and LVEF were important influencing factors of delayed readmission after PCI (all $p < 0.05$). Follow-up results showed that 125 patients survived and nine died among the delayed non-readmission patients after PCI. Among the patients with delayed readmission, 95 survived and 29 died. Kaplan–Meier survival analysis showed that the survival time of patients with delayed non-readmission was longer than that of patients with delayed readmission, and the difference was statistically significant ($\chi^2 = 17.696$, $p < 0.001$). **Conclusion**: Age, COPD, history of oral anticoagulant drugs, and LVEF are important influencing factors of delayed readmission after PCI, and the survival time of patients with delayed non-readmission is longer than that of patients with delayed readmission.

Keywords

percutaneous coronary intervention; acute myocardial infarction; late readmission; survival analysis

Introduction

Acute myocardial infarction is one of the most serious diseases in coronary heart disease, with a high incidence and critical condition [1]. Percutaneous coronary intervention (PCI) is one of the important methods for treating acute myocardial infarction [2]. In recent years, the proportion of PCI has been as high as 38.9% [3,4]. Timely and effective opening of an infarct artery in the early stage of acute myocardial infarction can improve the symptoms of myocardial hypoxia and ischemia by dredging or dilating occlusive or narrow coronary arteries [5]. It is helpful in saving dying cardiomyocytes, improving cardiac function, reducing mortality, and improving the quality of life and prognosis [6]. However, PCI can relieve stenosis only [7,8]. If the risk factors of coronary heart disease continue to exist, patients could still have myocardial infarction and cardiogenic death after the operation, and they need to be hospitalized again [9].

Late readmission after PCI refers to re-hospitalization after 1–12 months of discharge after PCI [10]. The prognosis of PCI is uncertain. Recurrent angina pectoris, chest pain, and acute myocardial infarction can lead to late readmission after PCI [11]. The late readmission of patients after PCI not only increases the economic burden of the patients but also increases the social medical burden [12]. In Western countries, readmission rates are included in medical quality indicators, and hospitals with readmission rates that exceed the benchmark are subject to financial penalties in accordance with the relevant legislation [13]. There-

Table 1. Results of comparison of clinical data between readmitted patients and non-readmitted patients [M (P25, P75)/n (%)].

Project		No readmission (n = 134)	Readmission (n = 124)	Z/χ^2	*p*
Gender	Male	86 (64.18)	84 (67.74)	0.364	0.546
	Female	48 (35.82)	40 (32.26)		
Age (years)		60.00 (52.00, 67.00)	63.00 (55.00, 70.00)	−2.726	0.006
BMI (kg/m^2)		23.08 (22.62, 23.59)	22.99 (22.52, 23.38)	−1.053	0.292
Family history of acute myocardial infarction	Yes	35 (26.12)	28 (22.58)	0.437	0.509
	No	99 (73.88)	96 (77.42)		
Coexisting COPD	Yes	4 (2.99)	15 (12.10)	7.838	0.005
	No	130 (97.01)	109 (87.90)		
History of chronic kidney disease	Yes	12 (8.96)	13 (10.48)	0.172	0.678
	No	122 (91.04)	111 (89.52)		
History of hypertension	Yes	31 (23.13)	51 (41.13)	9.619	0.002
	No	103 (76.87)	73 (58.87)		
History of diabetes mellitus	Yes	25 (18.66)	22 (17.74)	0.036	0.849
	No	109 (81.34)	102 (82.26)		
History of smoking	Yes	18 (13.43)	18 (14.52)	0.063	0.802
	No	116 (86.57)	106 (85.48)		
History of alcohol consumption	Yes	16 (11.94)	16 (12.90)	0.055	0.815
	No	118 (88.06)	108 (87.10)		
History of oral anticoagulants	Yes	21 (15.67)	41 (33.06)	10.672	0.001
	No	113 (84.33)	83 (66.94)		
LVEF (%)	≥50	92 (68.66)	41 (33.06)	36.301	≥0.001
Family history of acute myocardial infarction	45–49	25 (18.66)	35 (28.23)		
Coexisting COPD	35–44	13 (9.70)	31 (25.00)		
	<35	4 (2.99)	14 (13.71)		
History of chronic kidney disease	1	84 (62.69)	70 (56.45)	1.330	0.514
	2, 3	46 (34.33)	48 (38.71)		
	≥4	4 (2.99)	6 (4.84)		
History of hypertension	1	63 (47.01)	57 (45.97)	0.214	0.899
	2	47 (35.07)	42 (33.87)		
	3	24 (17.91)	25 (20.16)		

BMI, body mass index; COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction.

fore, understanding the situation of late readmission after PCI and its relationship with prognosis is important to reduce late readmission after PCI and reduce the economic and social medical burden of patients [14,15]. In the present article, the causes, the influencing factors and prognosis of patients with late readmission after PCI were reviewed to reduce the incidence of late readmission and improve the quality of life, survival rate, and prognosis of patients after PCI.

Materials and Methods

Study Design and Participants

This study was a retrospective cohort study conducted in West China Hospital, Sichuan University/West China School of Nursing, Sichuan University. As a tertiary public hospital, the medical records were recorded and stored in electronic form on the hospital's electronic information system, and strict and uniform standards for its completion and uploading were followed. A total of 368 patients with acute myocardial infarction who underwent PCI from January 2018, to January 2021, were identified through a case management system. The inclusion criteria were as follows: (1) aged >18 years old and (2) complete clinical data. The exclusion criteria were as follows: (1) in-hospital death, transfer, or uncured discharge; (2) incomplete data; and (3) interruption of follow-up. After 110 patients who did not meet the criteria were excluded, 258 patients were finally included. The patients were divided into two groups in accordance with whether they were readmitted within 1–12 months after being cured and discharged: readmitted group and non-readmitted group. Privacy and ethical standards were followed in this study, data were anonymized to protect patient privacy, and all study subjects provided informed consent. This study was approved by the Ethics Committee of West China Hospital, Sichuan University/West China School of Nursing, Sichuan University (R122017019).

Data Collection and Definition

In this study, the clinical data of the study subjects were obtained, recorded, and calculated through the case management system of West China Hospital, Sichuan University/West China School of Nursing, Sichuan University, which ensured data integrity and accuracy.

The baseline data were as follows: gender, age, body mass index (BMI), family history of acute myocardial infarction, and chronic obstructive pulmonary disease (COPD), history of chronic kidney disease, history of hypertension, history of diabetes, history of smoking, history of drinking, and history of oral anticoagulant drugs. BMI was calculated as weight in kg divided by the square of height in meters (kg/m^2).

The clinical examination datum was left ventricle ejection fraction (LVEF).

The PCI treatment data were as follows: number of stents implanted and number of diseased vessels.

Follow-Up Endpoint

The primary endpoint was all-cause mortality, and the survival time was calculated in months. The starting point was the discharge time of the non-readmission patients and the discharge time of the readmission patients after readmission, and the endpoint was the time of the occurrence of an endpoint event (survival or death). The end time of follow-up was defined as the end time of no endpoint event.

Statistical Method

Descriptive statistics was used to profile the distribution of baseline characteristics of readmitted patients and non-readmitted patients. For categorical variables, chi-square test was performed and represented by [n (%)]. For continuous variables, the Shapiro–Wilk test was used to evaluate whether they conformed to normal distribution ($p > 0.05$, normal). Continuous variables with non-normal distributions were expressed as median (M) and quartile distances (P25, P75), and non-parametric tests were used to compare group differences. In this study, continuous variables did not conform to normal distribution, so the non-parametric tests were performed, and they were presented as M (P25, P75).

Delayed readmission was used as the dependent variable in analyzing the influencing factors of readmission. The statistically significant variables ($p < 0.05$) from the unadjusted model were used to run a multivariate logistic regression to examine the association between delayed readmission and various correlates. The strength of any association was expressed as the odds ratios (ORs) and 95% confidence intervals (CI). The covariates in the multivariate model were tested for multicollinearity by estimating the variance inflation factor (VIF), and all variables with VIF values above 10 were considered colinear. No multicollinearity was found in this study after testing. The Kaplan–Meier method was used to analyze the survival of readmitted patients and draw the survival curve.

All statistical analyses were performed in SPSS software (version: 25.0; manufacturer: International Business Machines Corporation, Armonk, NY, USA), and $p < 0.05$ was considered statistically significant.

Table 2. Variable assignment.

Variable	Assign value
Delayed readmission	1 = readmission, 0 = no readmission
Age	Continuous variables
Whether combined with COPD	1 = yes, 0 = no
History of hypertension	1 = yes, 0 = no
History of oral anticoagulants	1 = yes, 0 = no
LVEF	1 = <50%, 0 = ≥50%

Result

Comparison of Clinical Data between Readmitted Patients and Non-Readmitted Patients

Significant differences were found in age, COPD, history of hypertension, history of oral anticoagulants, and LVEF between readmission patients and non-readmission patients ($p < 0.05$). No significant differences were observed in gender, BMI, family history of acute myocardial infarction, history of chronic kidney disease, history of diabetes, history of smoking, history of drinking, and the number of implanted stents and diseased vessels ($p > 0.05$, Table 1).

Logistic Regression Analysis of Influencing Factors of Delayed Readmission after PCI

The delayed readmission was used as the dependent variable, and age, history of COPD, history of premature coronary heart disease, history of hypertension, history of oral anticoagulant drugs, and LVEF were used as independent variables. The readmission index was assigned a value of 1 for "readmitted" and a value of 0 for "not readmitted". "Yes" was assigned a value of 1, and "no" was assigned a value of 0. "Yes" was assigned to 1, and "no" was assigned to 0 for the history of premature coronary heart disease. History of hypertension was assigned a value of 1 for "yes" and a value of 0 for "no". "Yes" was assigned a value of 1 and "no" was assigned a value of 0 for the oral anticoagulant history indicator. For LVEF, "<50%" was assigned as 1 and "≥50%" was assigned as 0. The age variable was a continuous variable (Table 2).

Table 3. Logistic regression analysis of influencing factors for delayed readmission after PCI treatment.

Influencing factor	β	Standard error	Walds	p	OR	95% CI
Age	0.046	0.017	7.371	0.007	1.047	1.013–1.082
Whether combined with COPD	1.730	0.642	7.253	0.007	5.641	1.602–19.871
History of hypertension	0.627	0.322	3.784	0.052	1.873	0.995–3.523
History of oral anticoagulants	1.074	0.361	8.855	0.003	2.926	1.443–5.936
LVEF	1.672	0.303	30.396	<0.001	5.321	2.937–9.641

PCI, percutaneous coronary intervention; OR, odds ratio; CI, confidence interval.

The results of binary logistic regression analysis showed that age, COPD, history of premature coronary heart disease, history of oral anticoagulant drugs, and LVEF were important influencing factors of delayed readmission after PCI (all $p < 0.05$, Table 3).

Survival Analysis of Patients with Delayed Readmissions and Non-Readmissions after PCI

The follow-up results showed that 125 patients survived and nine died among the delayed non-readmission patients after PCI. Among the patients with delayed readmission, 95 survived and 29 died. The results of Kaplan–Meier survival analysis showed that the survival time of patients with delayed non-readmission was longer than that of patients with delayed readmission, and the difference was statistically significant (χ^2 = 17.696, $p < 0.001$, Fig. 1).

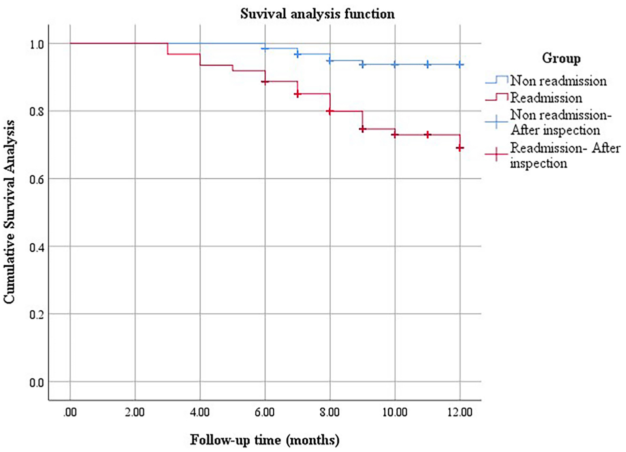

Fig. 1. Overall survival curves for delayed readmissions and non-readmission.

Discussion

At present, PCI is the key treatment for acute myocardial infarction [16], but postoperative readmission is still common after PCI, and it could bring a large economic burden to patients. The logistic regression analysis showed that age, COPD, history of oral anticoagulant drugs, and LVEF were important influencing factors for delayed readmission after PCI.

This study found that age was the influencing factor of delayed readmission after PCI, which was consistent with the findings of Freites *et al*. [17]. With the increase in age, myocardial cells gradually become fibrotic, the endocardium of the heart gradually thickens, and blood vessels go through aging phenomenon. Therefore, the prognosis of elderly patients is usually poor, and the possibility of delayed readmission after PCI is higher [18]. In addition, elderly patients often have multiple chronic conditions, such as high blood pressure, which increase the risk of complications after PCI. Doctors and nurses must pay close attention to the situation of elderly patients, strengthen follow-up, and take individualized nursing measures to ensure the safety and rehabilitation of patients.

COPD is a lung disease characterized by airflow limitation, and various mechanisms have proven to be closely related to coronary heart disease. One of the mechanisms is that patients with COPD have increased oxidative stress, hypoxia, and systemic inflammation; a large number of inflammatory mediators enter the circulation, resulting in impaired vascular endothelial function and subsequent instability of the cardiac conduction system, thus increasing the possibility of cardiovascular events [19]. The present study found that COPD was an influencing factor of delayed readmission after PCI, consistent with the research results of Yao *et al*. [19]. Patients with COPD have poor lung function, and after PCI treatment, respiratory function may be further limited, and PCI treatment could suppress the immune system. Patients may also increase the risk of infection. The increase in pulmonary artery pressure caused by COPD can lead to enlargement of the right ventricle and reduction in left ventricular diastolic pressure and systolic pressure-volume, which, in turn, reduces ejection fraction and cardiac function, affects the prognosis of patients after PCI, and increases the possibility of delayed readmission after PCI [20]. Therefore, the disease management of patients with COPD must be strengthened. Special attention should be paid to these issues after PCI, and appropriate measures should be taken to reduce the risk of delayed readmission.

This study found that patients with a history of oral anticoagulants after PCI had a higher risk of readmission than those without a history of oral anticoagulants, and history of oral anticoagulants was a risk factor for readmission, consistent with the study results of Vidula *et al*. [21]. Oral anticoagulants can effectively reduce thrombosis and vascular restenosis in patients after PCI, but they also increase the risk of adverse reactions such, as bleeding, which could affect the prognosis and readmission rate of patients. Therefore, when using oral anticoagulants, conducting individualized assessments and decision-making in accordance with the specific conditions of patients is necessary to minimize the risk of adverse reactions and improve the prognosis and quality of life of patients.

In addition, LVEF was found to be an important risk factor for delayed readmission after PCI. In patients with acute myocardial infarction, the degree of myocardial injury is important to evaluate the therapeutic effect and prognosis, and LVEF is an important indicator to reflect the degree of myocardial injury. Clinical studies have shown that LVEF reduction is one of the risk factors for poor prognosis [22,23]. Decreased LVEF indicates that the left ventricular systolic function is decreased and the heart's ability to pump blood is weakened, which may lead to poor patient prognosis and increased readmission rate. Therefore, LVEF needs to be closely monitored and evaluated after PCI, and abnormal cardiac function should be found and treated in time to reduce the risk of readmission.

This study also found that the effect of a history of hypertension on delayed readmission after PCI did not reach a statistical significance level, but hypertension is one of the known important risk factors for cardiovascular disease and cannot be ignored. Long-term hypertension may lead to the thickening of the vascular wall and the reduction in vascular elasticity, which may increase the risk of restenosis and thrombosis after PCI, which may then lead to the occurrence of readmission. Therefore, for patients with a history of hypertension after PCI, blood pressure management and follow-up should be strengthened to reduce the risk of readmission.

In the survival analysis, delayed non-readmitted patients had longer survival time than delayed readmitted patients, suggesting that readmission may affect the prognosis and survival rate of patients. Therefore, in clinical practice, doctors should pay attention to the follow-up and management of patients after PCI and timely find and deal with risk factors that may lead to readmission to improve the survival rate and prognosis quality of patients.

Limitation

This study has some limitations. First, it was a single-center study with a small sample size and lacked external validation. The results were more of a baseline study and a supplement to this field. Second, various biases could be observed in retrospective studies unavoidably. In this study, potential selection bias may appear, and the readmission of patients may be underestimated, because the readmission patients were frequently severe, and relatively minor patients may not be readmitted. Therefore, surveillance is necessary for those patients and prospective multicenter studies must be conducted to further address the situation. The follow-up time must be extended to further explore the long-term outcomes of acute myocardial infarction (AMI) patients after PCI to help improve their outcomes. Third, some other potential factors were not considered, such as physical activity, social and economic factors, and medical institution factors. Further refinement is needed in future studies. Finally, this study analyzed and discussed only the rate of terminal events and survival in the two groups during a 12-month follow-up period. The stable survival rate could not represent the long-term prognosis. In future studies, a long-term follow-up period of recurrent patients, such as beyond the 12-month follow-up period, will be conducted to understand their long-term prognosis and provide a reference for the health management of patients.

Conclusion

Age, presence or absence of COPD, history of oral anticoagulants, and LVEF are important influencing factors of delayed readmission after PCI, and the survival time of delayed non-readmission patients is longer than that of delayed readmission patients. This study provides valuable information to further understand the influencing factors related to delayed readmission after PCI among patients with acute myocardial infarction. Using rational and effective early preventive measures could reasonably manage the health of these patients and improve the burden caused by this issue.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

LZ performed the statistical analysis. SP interpreted the data. JC interpreted the findings and drafted the manuscript. SP designed and supervised the study. All authors reviewed the manuscript, edited it for intellectual content, and gave final approval for this version to be published. LZ is the guarantor of this work and, as such, had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Ethics Approval and Consent to Participate

Privacy and ethical standards were followed in this study, data were anonymized to protect patient privacy, and all study subjects provided informed consent. This study was approved by the Ethics Committee of West China Hospital, Sichuan University/West China School of Nursing, Sichuan University (R122017019).

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Conflict of Interest

The authors declare no conflict of interest.

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