

Analysis of Influencing Factors of Unplanned Readmission in Patients With Acute Coronary Syndrome Within 30 Days After PCI

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ABSTRACT

Objective: The purpose of this study is to identify the influencing factors of unplanned readmission in patients with the acute coronary syndrome (ACS) within 30 days after percutaneous coronary intervention (PCI).

Methods: From November 1, 2018, to October 31, 2019, the clinical data of 1277 patients with acute coronary syndrome and percutaneous coronary intervention retrospectively were collected. After screening by exclusion and rejection criteria, a total of 936 patients finally entered the study. Patients were divided into the readmission group (57 cases) and the non-readmission group (879 cases), according to whether unplanned readmission occurred within 30 days after PCI. To analyze the influence of patients' age, past disease history, medication history, laboratory data, vascular diseases, and other factors on readmission and the clinical characteristics of readmission patients.

Results: Fifty-seven patients had unplanned readmission within 30 days, and the readmission rate was 6.09%. The clinical features of readmission patients are older age, longer hospitalization days, more emergency percutaneous coronary intervention, more patients with diabetes history, and more patients diagnosed with ST-segment elevation myocardial infarction and non-ST-segment elevation myocardial infarction. Logistic regression analysis revealed that smoking index, number of diseased vessels, ACEF score, diabetes, and PCI status were the influencing factors of unplanned readmission of ACS patients within 30 days after PCI.

Conclusion: Smoking index, number of diseased vessels, ACEF score, diabetes, and PCI status are the influencing factors of unplanned readmission within 30 days after percutaneous coronary intervention for patients with acute coronary syndrome.

INTRODUCTION

Acute coronary syndrome (ACS) is a common and serious cardiovascular disease that refers to any type of symptoms caused by coronary artery occlusion. In China, the mortality and incidence rate of ACS is increasing [Shengshou 2019]. Percutaneous coronary intervention (PCI) as the most common way of vascular reconstruction in patients with ACS is also on the rise. In 2017, the number of PCI patients in the Chinese mainland was 753142, with an average number of 1.47 stent implantation, and the mortality rate of PCI patients remained at a low level (0.23%) [Shengshou 2019]. The growth of PCI is global, and it also has occurred in other countries, such as the United States, India and Japan [Epstein 2011; Kwok 2018; Kwok 2016].

However, with the popularity of PCI, more and more people pay attention to the unplanned readmission after PCI. The prognosis of PCI is uncertain, such as recurrent angina pectoris, chest pain, recurrent acute myocardial infarction and so on, which will lead to the readmission of patients after PCI.

Previous studies have explored risk factors and predictive models to identify high-risk patients who are readmitted within 30 days after PCI [Hannan 2011; Fanari 2017; Tripathi 2017; Yost 2013]. However, there are few studies on unplanned readmission of ACS patients within 30 days after PCI. Considering the differences between ACS patients and other cardiovascular disease patients, the results of previous studies may not be directly applicable to ACS patients. Therefore, it is necessary to explore the risk factors of unplanned readmission 30 days after PCI in patients with ACS.

METHODS

Ethics approval and consent to participate: The study protocol was approved by the Ethics Committee of The Second Affiliated Hospital of Zhejiang University. Informed consent was obtained from all the study subjects before enrollment.

The clinical data of 1277 patients with ACS and PCI retrospectively were collected in Zhejiang province, China. The electronic medical record system was used to collect patients' cases and establish a database. Patients were divided into the readmission group and non-readmission group, according to whether unplanned readmission occurred within 30 days

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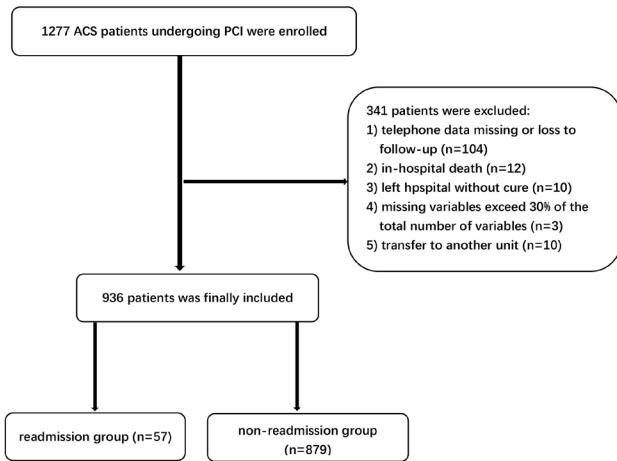


Figure 1. The flowchart depicts the exclusion of the patients. PCI indicates percutaneous coronary

after PCI. Whether there was unplanned readmission within 30 days was determined by telephone follow-up.

Exclusion criteria: < 18 years old, in-hospital death, left the hospital without a cure, have a cognitive function or mental disorder, telephone data missing or loss to follow up, missing variables exceed 30% of the total number of variables, transfer to another hospital and planned readmission. According exclusion criteria, 341 cases were excluded (telephone data missing or loss to follow up, $N = 104$), in-hospital death ($N = 12$), left hospital without cure ($N = 10$), missing variables exceed 30% of the total number of variables ($N = 3$), transfer to another hospital ($N = 10$), and planned readmission ($N = 202$). Finally, 936 cases were included in this study (readmission group, $N = 57$) and non-readmission group ($N = 879$). (Figure 1)

The diagnostic criteria for all variables were based on current ESC guidelines. Age, gender, marital status, educational background, BMI, smoking index, history of diabetes, history of hypertension, and medication history of all cases were collected. White blood cells, red blood cells, platelets, albumin, and lymphocytes were collected from all cases at the time of admission. ACEF score was calculated retrospectively, according to the following formula: $ACEF = age / LVEF + 1$ (if creatinine > 2.0 mg / dl) [Ranucci 2009].

SPSS 23.0 was used for statistical analysis. The normal measurement data were expressed as mean ± SD, and the comparison between groups was performed by t-test. Non-normal measurement data were expressed by median and quantile, and the comparison between groups was conducted by a nonparametric test. The count data were expressed by frequency and rate (%), and Chi-square test was used for comparison between groups. The risk factors were analyzed by logistic regression. $P < 0.05$ was statistically significant.

RESULTS

A total of 936 patients with ACS and PCI, from November 1, 2018, to October 30, 2019, were included in this study. The

Table 1. Causes of 30-day unplanned readmission

Causes of readmission	30-day unplanned readmission, N (%)
Causes of cardiac readmissions	
Unstable angina	19 (33.3%)
Acute myocardial infarction	10 (17.5%)
Chest pain	6 (10.5%)
Heart failure	3 (5.3%)
Old myocardial infarction	1 (1.8%)
Subacute myocardial infarction	1 (1.8%)
Arrhythmia	1 (1.8%)
Other	3 (5.3%)
Causes of non-cardiac readmissions	
DM	4 (7.0%)
Fever	2 (3.5%)
Pulmonary infection	1 (1.8%)
Uremia	1 (1.8%)
Pleural effusion	1 (1.8%)
Gastro-intestinal	1 (1.8%)
Cerebral infarction	1 (1.8%)
Other	2 (3.5%)

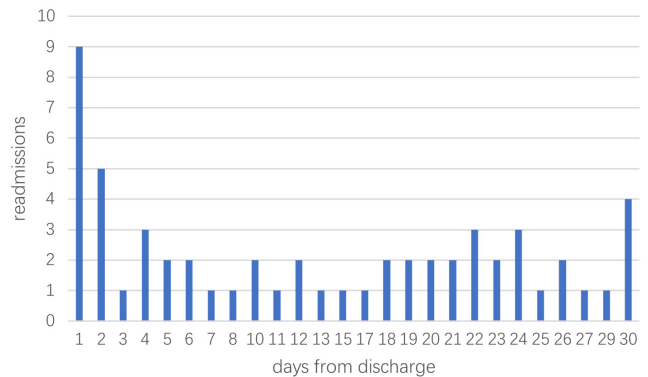


Figure 2. Time course of 30-day unplanned readmissions

average age was 63.73 ± 11.93 years and 718 patients (76.7%) were males. The 30-day unplanned readmission rate was 6.09%. Table 1 shows the causes of 30-day unplanned readmission. (Table 1) Figure 2 shows the days from discharge to readmission. (Figure 2) Table 2 shows their baseline clinical and demographic features. (Table 2) Patients in the readmission group generally had diabetes (38.6% vs. 25.5%), STEMI (26.3% vs. 18.1%), NSTEMI (29.8% vs. 14.6%), urgency PCI (33.9% vs. 18.4%), the use of insulin (12.3% vs. 5.1%), higher smoking index [375 (0, 600) vs. 150 (0, 450)], lower LVEF (54.70 ± 12.16 vs. 61.11 ± 10.42), higher ACEF score [1.21 (0.93, 1.69) vs. 1.01 (0.86, 1.21)], longer lengths of stay

Table 2. Baseline characteristics of the study population

Variables	Readmission group (N = 57)	Non-readmission group (N = 879)	P
Age [M (Q1, Q3), years]	67.00 (61.50, 73.50)	64.00 (56.00, 72.00)	0.056
Length of stay [M (Q1, Q3)]	5 (4, 9)	4 (3, 6)	0.001
BMI ($\bar{x}\pm s$, Kg/m ²)	24.02 \pm 3.43	24.60 \pm 3.14	0.178
Gender	-	-	0.815
Male, n (%)	43 (75.4%)	675 (76.8%)	
Female, n (%)	14 (24.6%)	204 (23.2%)	
Marital status	-	-	0.741
Married, n (%)	55 (96.5%)	819 (93.2%)	
Unmarried, n (%)	0 (0%)	7 (0.8%)	
Divorced, n (%)	0 (0%)	6 (0.7%)	
Widowed, n (%)	2 (3.5%)	47 (5.3%)	
Admission day -	-	0.311	
Weekend, n (%)	12 (21.1%)	239 (27.2%)	
Weekday, n (%)	45 (78.9%)	640 (72.8%)	
NYHA	-	-	0.246
I, n (%)	9 (16.4%)	231 (26.8%)	
II, n (%)	37 (67.3%)	529 (61.4%)	
III, n (%)	8 (14.5%)	97 (11.3%)	
IV, n (%)	1 (1.8%)	5 (0.6%)	
PCI	-	-	0.004
Optional date, n (%)	37 (66.1%)	714 (81.6%)	
Urgency, n (%)	19 (33.9%)	161 (18.4%)	
Payment -	-	0.014	
Medicare, n (%)	19 (33.3%)	441 (50.2%)	
Self-pay, n (%)	39 (66.7%)	438 (49.8%)	
Diagnosis	-	-	0.001
STEMI, n (%)	15 (26.3%)	159 (18.1%)	
NSTEMI, n (%)	17 (29.8%)	128 (14.6%)	
UA, n (%)	25 (43.9%)	592 (67.3%)	
Aspirin, n (%)	18 (31.6%)	317 (36.1%)	0.494
Insulin, n (%)	7 (12.3%)	45 (5.1%)	0.023
Smoking index [M (Q1, Q3)]	375 (0, 600)	150 (0, 450)	0.046
Drinking, n (%)	28 (49.1%)	438 (49.9%)	0.911
Hypertension, n (%)	28 (49.1%)	511 (58.1%)	0.182
DM, n (%)	22 (38.6%)	224 (25.5%)	0.029
Previous PCI, n (%)	15 (26.3%)	272 (30.9%)	0.463
LVEF ($\bar{x}\pm s$, %)	54.70 \pm 12.16	61.11 \pm 10.42	<0.001
ACEF score [M (Q1, Q3)]	1.21 (0.93, 1.69)	1.01 (0.86, 1.21)	<0.001

BMI, body mass index; DM, diabetes mellitus; Previous PCI, previous percutaneous coronary intervention; LVEF, left ventricular ejection fraction

Table 3. Laboratory measurements of the study population

Variables	Readmission group (N = 57)	Non-readmission group (N = 879)	P
WBC [M (Q1, Q3), ×10 ⁹ /L]	7.00 (5.55, 9.60)	6.80 (5.60, 8.60)	0.478
RBC [M (Q1, Q3), × 10 ¹² /L]	4.40 (3.89, 4.80)	4.48 (4.11, 4.85)	0.313
PCV [M (Q1, Q3), %]	0.39 (0.35, 0.43)	0.41 (0.97, 0.43)	0.412
Lymphocyte (x±s, ×10 ⁹ /L)	1.52±0.71	1.73±0.72	0.03
Hb (x̄±s,g/L)	133.33±22.89	138.40±18.33	0.107
Platelet (x̄±s, ×10 ⁹ /L)	204.09±64.85	205.31±57.29	0.877
Neutrophil [M (Q1, Q3), ×10 ⁹ /L]	4.59 (3.62, 6.70)	4.30 (3.38, 5.83)	0.274
CK [M (Q1, Q3), U/L]	129.00 (65.50, 237.50)	93.00 (68.00, 159.00)	0.166
CK- MB [M (Q1, Q3), ng/mL]	18.00 (13.50, 28.50)	15.00 (12.00, 21.00)	0.05
BUN [M (Q1, Q3), mmol/L]	6.40 (4.90, 9.10)	5.71 (4.78, 6.97)	0.169
Glucose [M (Q1, Q3), mmol/L]	8.00 (6.30, 11.74)	7.13 (6.04, 9.19)	0.052
Creatinine [M (Q1, Q3), μmol/L]	80.00 (65.50, 99.00)	73.00 (63.00, 85.00)	0.273
HDL (x̄±s, mmol/L)	1.07±0.29	1.12±0.24	0.142
LDL [M (Q1, Q3), mmol/L]	2.28 (1.76, 2.87)	1.95 (1.46, 2.55)	0.084
Albumin (x̄±s, g/L)	36.54±4.43	38.16±3.47	0.009
BNP [M (Q1, Q3)]	157.80 (47.90, 414.00)	58.85 (26.20, 169.93)	0.046
CRP [M (Q1, Q3), mg/L]	7.75 (5.00, 14.13)	5.00 (5.00,6.10)	0.001

INR, international normalized ratio; WBC, white blood cell; Hb, hemoglobin; RBC, red blood cell; HDL, high density lipoprotein; LDL, low density lipoprotein; PCV, packed cell volume; CK, creatine kinase; CRP, C-reactive protein

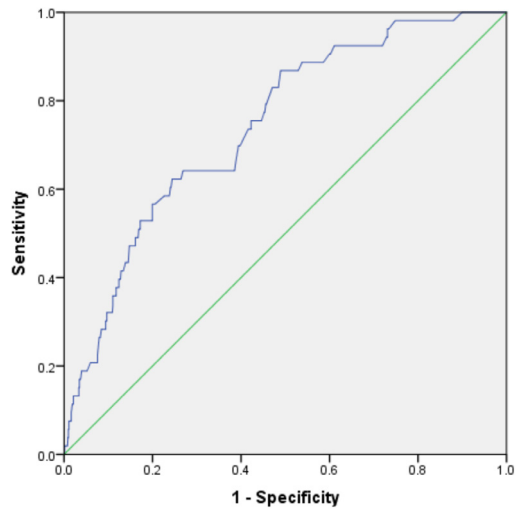


Figure 3. Receiver-operating curve (ROC) analysis shows the optimal cutoff value of the model for 30-day unplanned readmission. AUC=0.742

[5(4, 9) vs. 4(3, 6)], and more self-pay (66.7% vs. 49.8%) than patients in the non-readmission group.

Table 3 shows baseline laboratory findings. (Table 3) Baseline albumin was significantly lower in the readmission group compared with the non-readmission group (36.54±4.43 vs. 38.16±3.47, *P* = 0.009). Patients in the readmission group had significantly lower lymphocyte, albumin, but higher CK-MB, brain natriuretic peptide (BNP), CRP, when compared with patients in the non-readmission group.

Table 4 shows angiographic and procedural characteristics. (Table 4) Patients in the readmission group had significantly more diseased vessels, left circumflex (LC), right coronary artery (RCA), and multivessel disease. There were no significant differences in left main stem (LM), left anterior descending (LAD), operation time, and contrast dose between the two groups.

Table 5 shows the independent predictors of 30-days unplanned readmission identified by logistic regression analysis. (Table 5) Length of stay, smoking index, number of diseased vessels, ACEF score, DM, and albumin were associated with 30-days unplanned readmission. Furthermore, multivariate logistic regression analysis revealed that smoking index, number of diseased vessels, ACEF score, DM, and PCI status (urgency) were independent predictors of 30-days unplanned readmission.

Figure 3 shows the value of the model in predicting 30-days unplanned readmission revealed by ROC curve analysis. (Figure 3) The area under the curve was 0.742.

DISCUSSION

This study revealed that smoking index, multi-vessel disease, ACEF score, PCI status, and diabetes were the influencing factors for 30 days of unplanned readmission of ACS patients after PCI. For the first time, this study identified the influencing factors of unplanned readmission of patients with the acute coronary syndrome (ACS) in China within 30 days after percutaneous coronary intervention (PCI).

Table 4. Angiography and procedural of the study population

Variables	Readmission group (N = 57)	Non-readmission group (N = 879)	P
Number of diseased vessels [M (Q1, Q3)]	2.50 (1.25, 3.00)	2.00 (1.00, 2.00)	<0.001
LM, n (%)	9 (16.1%)	87 (9.9%)	0.141
LAD, n (%)	49 (87.5%)	716 (81.5%)	0.262
LC, n (%)	34 (60.7%)	397 (45.2%)	0.024
RCA, n (%)	37 (66.1%)	432 (49.3%)	0.015
Multivessel disease, n (%)	36 (63.2%)	378 (43.1%)	0.003
Operation time [M (Q1, Q3), min]	58.00 (40.00, 80.00)	64.00 (43.75, 90.00)	0.233
Contrast dose [M (Q1, Q3), ml]	120 (90, 140)	120 (100, 140)	0.834

LM, left main stem; LAD, left anterior descending; LC, left circumflex; RCA, right coronary artery

Table 5. Factors predicting readmission on logistic regression analysis

Variables	Univariate analysis OR (95% CI)	P	Multivariate analysis OR (95% CI)	P
Age	1.021 (0.998-1.045)	0.079		
Male	0.928 (0.498-1.731)	0.815		
Length of stay	1.086 (1.026-1.149)	0.005		
Hypertension	0.695 (0.407-1.189)	0.184		
Smoking index	1.001 (1.000-1.002)	0.021	1.001 (1.000-1.002)	0.009
Number of diseased vessels	1.758 (1.299-2.379)	<0.001	1.579 (1.143-2.182)	0.006
ACEF score	2.765 (1.751-4.366)	<0.001	1.744 (1.215-2.504)	0.003
DM	1.838 (1.056-3.200)	0.031	1.950 (1.081-3.520)	0.027
Albumin	0.883 (0.821-0.950)	0.001		
PCI status (urgency)	2.227 (1.276-4.063)	0.005	1.910 (1.031-3.539)	0.040
Payment (self-pay)	2.014 (1.143-3.548)	0.015		

Smoking has a strong effect on promoting thrombosis [Chow 2010]. Smoking also will increase the risk of cardiovascular disease [Ya 2020]. Therefore, patients with a higher smoking index may have a higher risk of readmission. Quitting smoking is the most economical intervention to reduce the risk of cardiovascular disease and death. Studies have shown that the mortality of patients with coronary heart disease after quitting smoking has been reduced by 36% [Critchley 2003]. Barywani et al. found that the risk of all-cause readmission in patients with acute coronary syndrome aged 80 years or older with a smoking history increased within 5 years after PCI [Barywani 2016]. Lam et al. found that smoking history is a risk factor for all-cause readmission of ACS patients within 30 days after PCI [Lam 2019]. Clinicians should keep abreast of patients' tobacco use, actively persuading patients to quit smoking and informing them of the harm of smoking to health. Clinicians also should evaluate patients' willingness to quit smoking and their dependence on tobacco and make a smoking cessation plan to help deal with the adverse reactions caused by smoking cessation. For patients who don't want to

quit smoking, medical staff should constantly encourage them to quit smoking and remind them of the benefits of doing so.

ACEF scores included age, creatinine, and ejection fraction. It is a common scoring tool used to predict the occurrence of cardiovascular adverse events. Age, serum creatinine level, and ejection fraction are all related to poor prognosis after PCI [Spitzer 2017; Ya 2020]. ACEF score is a simple and convenient clinical evaluation tool including only three variables. Clinicians should evaluate ACS patients with an ACEF score during their hospitalization. We should pay attention to patients with high risk and reduce unplanned readmission. Moretti et al. found that the ACEF score is an independent predictor of major adverse cardiac events and all-cause death within 30 days after PCI, which is similar to the results of this study [Moretti 2015].

In patients with diabetes mellitus, oxidative stress caused by elevated blood sugar and the function of ischemia-reperfusion induced by non-oxidative glucose pathway impairing cardiac contraction, endothelial injury, and inflammatory reaction in blood vessels in patients with diabetes mellitus

cause damage to myocardial cells of patients, which makes them have a higher risk of readmission [Ya 2020; Mapanga 2014]. Kwok et al. found that diabetes is a risk factor for readmission in 30 days after PCI [Kwok 2018]. In China, when a patient is admitted to a hospital, the medical staff will evaluate the patient's admission. Generally, whether the patient has diabetes can be known by asking the patient or the family members of the patient, or whether the patient has diabetes can be diagnosed by clinical examination technology or other tests. For ACS patients with diabetes mellitus, medical staff should monitor and manage the blood sugar in time, identify the adverse complications caused by diabetes mellitus at an early stage, and carry out the symptomatic treatment.

The existence of multi-vessel disease and urgent PCI increases the risk of unplanned readmission of patients, which may be related to the poor vascular condition, advanced age, and other complications, or serious illness of patients with multi-vessel disease.

Limitations: This study has some limitations. First, due to the limitations of retrospective study, some data may be incomplete. Second, the sample size of this study is small. Finally, the results of this study are based on a single research center, which is not representative enough. Therefore, more prospective and large sample multicenter studies are needed in the future.

CONCLUSION

This study found that PCI status, smoking index, multi-vessel disease, ACEF score, and diabetes were the influencing factors of unplanned readmission within 30 days after PCI.

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