Analysis of influencing factors of revascularization after percutaneous coronary intervention in patients with coronary heart disease and construction of nomogram model

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Article

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Abstract

**Objective** To analyze the influencing factors of revascularization in patients with coronary heart disease after PCI, and to construct a Nomo diagram model of revascularization in patients with coronary heart disease after PCI and conduct internal verification.

**Methods** Patients with coronary heart disease who underwent PCI in the National Key Specialty Cardiology Department of a tertiary and first-class hospital in Zhenjiang City from January 2015 to November 2015 were retrospectively collected as the research subjects. Multivariate Logistic regression was used to analyze the influencing factors of repeat revascularization after PCI in patients with coronary heart disease, and a nomogram model was established to predict the risk of repeat revascularization after PCI in patients with coronary heart disease. The predictive performance of the model was internally validated using ROC curves.

**Results** Multivariate analysis showed that poor daily life behaviors [OR=4.208, 95%CI(1.828, 9.686)], high risk of coronary heart disease specific index [OR=3.308, 95%CI(1.157, 9.453)], high fat Hyperemia [OR=7.262, 95%CI(3.236, 16.296)], multivessel disease [OR=2.691, 95%CI(1.061, 6.822); OR=6.068, 95%CI(2.467, 14.925)] was coronary heart disease The independent risk factors of revascularization in patients (P<0.05) were included in the model. Model internal validation AUC value was 0.830 [95%CI (0.782, 0.870), P<0.05], Youden index was 0.5530, specificity was 85.48%, sensitivity was 69.81%, and cut-off value was 122.39 points.

**Conclusion** The main influencing factors of poor daily living behavior, high risk of coronary heart disease-specific index, hyperlipidemia and multivessel disease, the nomogram model established based on the above factors has good predictive performance.

1 Introduction

With the rapid development of society and economy, the incidence of coronary heart disease in my country has been rising, and it has become one of the main causes of adult death in my country [1]. At present, percutaneous coronary intervention (PCI) has become an important medical method for patients with coronary heart disease [2]. PCI can not only greatly reduce the mortality rate of patients with coronary heart disease, but also effectively stabilize the patient's condition, and has the characteristics of quick recovery and less trauma to patients [3]. However, in clinical work, it is found that some patients who receive PCI will still have stent restenosis or new coronary lesions, which requires revascularization, which will have a negative impact on the prognosis of patients [4]. In this study, the influencing factors of revascularization after PCI in patients with coronary heart disease were analyzed, and a nomogram model was established to predict the risk of revascularization in patients with coronary heart disease after PCI. In order to provide guidance for clinicians to identify patient risk factors and prevent revascularization.
2 Methods

2.1 Research objects

This study is a retrospective study, selected patients with coronary heart disease who underwent PCI in the National Key Specialty Cardiology Department of a tertiary and first-class hospital in Zhenjiang from January 2015 to November 2015 as the research subjects. Inclusion criteria: (1) Meet the diagnostic criteria of coronary heart disease [5]; (2) Successfully received PCI (surgical success criteria: residual vascular stenosis after PCI is less than 20%, TIMI blood flow > grade II) [6]. Exclusion criteria: (1) patients with severe hepatic and renal insufficiency; (2) patients with tumor and cachexia; (3) patients with a history of revascularization; (4) patients who were readmitted for treatment due to the fractional PCI strategy. Sample size calculation: In Logistic regression analysis, the recommended sample size is 10–15 times the number of variables. A total of 18 observation variables were included in this study, and 10% of the invalid questionnaires were considered, so the sample estimated size was 198–297. A total of 301 patients were included in this study.

2.2 Data Collection

A retrospective analysis method was used to collect the gender, age, activities of daily living, white blood cell count, platelet count, blood urea, D-dimer, fibrinogen, creatine kinase, lactate dehydrogenase, myoglobin, troponinI, brain natriuretic peptide, coronary heart disease specific index, Killip cardiac function class, left ventricular ejection fraction, hyperlipidemia, multisessel disease. Among them, daily life behaviors mainly include dinner satiety: eat dinner every day until you feel full; Smoking: more than 10 cigarettes per day; Heavy drinking: At least 3 times a week, the amount of drinking (white wine) is more than 250g or the daily drinking amount (white wine) is more than 750g; Fitness: The amount of exercise has not reached at least 3 days a week, at least 1 hour each time [7]. Patients who have any one or more of the above bad behaviors are identified as poor behaviors in daily life. The coronary heart disease specific index is a model specially used to evaluate the comorbidities of patients with coronary heart disease. Its risk factors include smoking 1 point, hypertension 1 point, stroke/TIA history 1 point, diabetes 2 points, diabetic complications 3 points, Chronic obstructive pulmonary disease 2 points, peripheral vascular disease 2 points, tumor/lymphoma/leukemia 2 points, moderate to severe renal insufficiency 7 points, metastatic cancer 5 points, with a total score of 26 points, ≥ 4 points are considered high-risk patients [8]. The reasons for readmission, coronary angiography, PCI data, and stent placement were recorded, and the subjects were divided into revascularization group and non-revascularization group according to whether PCI was performed or not.

The data used to support the findings of this study are available from the corresponding author upon request. We would like to acknowledge and are grateful to Dr. Songmei Cao for providing additional data from their studies. We would also like to acknowledge the Jiangsu University Library for facilitating this work. All research methods used in this study were conducted in accordance with relevant guidelines and regulations. All protocols in this study were approved by the Ethics Committee of the Affiliated Hospital of Jiangsu University with the informed consent of all subjects.
2.3 Statistical methods

Statistical analysis was performed using SPSS19.0 software. Enumeration data are expressed as percentages. Univariate analysis was performed using the chi-square test or the exact probability method. The variables with statistical significance in univariate analysis were used as independent variables, and whether revascularization was repeated as the dependent variable, multivariate Logistic regression analysis was performed. The Nomo graph model was established by using R software. Plot ROC curves to internally validate model prediction performance. P < 0.05 was considered to be statistically significant.

3 Results

3.1 Univariate analysis of revascularization after PCI in patients with coronary heart disease

A total of 301 patients were included in this study. There were 53 patients (17.61%) in the revascularization group and 248 patients (82.39%) in the non-revascularization group. The results of univariate analysis showed that the gender, age, white blood cell count, platelet count, blood urea, D-dimer, fibrinogen, creatine kinase, lactate dehydrogenase, troponin I, brain natriuretic peptide of the two groups of patients, Killip cardiac function classification, the difference cannot be considered statistically significant between the two groups (P > 0.05). There were statistically significant differences in daily living behavior, myoglobin, coronary heart disease-specific index, left ventricular ejection fraction, hyperlipidemia, and multivessel disease between the two groups (P < 0.05). (see Table 1).
Table 1
Univariate analysis of repeat revascularization in patients with coronary heart disease after PCI

<table>
<thead>
<tr>
<th>Item</th>
<th>non-revascularization group ($n = 248$)</th>
<th>revascularization group ($n = 53$)</th>
<th>$\chi^2$</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male [n(%)]</td>
<td>75(30.24)</td>
<td>16(30.19)</td>
<td>0.000</td>
<td>0.994</td>
</tr>
<tr>
<td>Age $\geq 60$ [n(%)]</td>
<td>182(73.39)</td>
<td>42(79.25)</td>
<td>0.787</td>
<td>0.375</td>
</tr>
<tr>
<td>Bad daily life behavior [n(%)]</td>
<td>47(18.95)</td>
<td>30(56.60)</td>
<td>32.519</td>
<td>0.001</td>
</tr>
<tr>
<td>Abnormal white blood cell count [n(%)]</td>
<td>41(16.53)</td>
<td>10(18.87)</td>
<td>0.169</td>
<td>0.681</td>
</tr>
<tr>
<td>Abnormal platelet count [n(%)]</td>
<td>25(10.08)</td>
<td>9(16.98)</td>
<td>2.075</td>
<td>0.150</td>
</tr>
<tr>
<td>Abnormal blood urea [n(%)]</td>
<td>25(10.08)</td>
<td>5(9.43)</td>
<td>0.020</td>
<td>0.887</td>
</tr>
<tr>
<td>Abnormal D-dimer [n(%)]</td>
<td>51(20.56)</td>
<td>11(20.75)</td>
<td>0.001</td>
<td>0.975</td>
</tr>
<tr>
<td>Abnormal fibrinogen [n(%)]</td>
<td>52(20.97)</td>
<td>11(20.75)</td>
<td>0.001</td>
<td>0.972</td>
</tr>
<tr>
<td>Abnormal creatine kinase [n(%)]</td>
<td>64(25.81)</td>
<td>12(22.64)</td>
<td>0.232</td>
<td>0.630</td>
</tr>
<tr>
<td>Abnormal lactate dehydrogenase [n(%)]</td>
<td>68(27.42)</td>
<td>16(30.19)</td>
<td>0.166</td>
<td>0.683</td>
</tr>
<tr>
<td>Abnormal myoglobin [n(%)]</td>
<td>116(46.77)</td>
<td>13(24.53)</td>
<td>8.824</td>
<td>0.003</td>
</tr>
<tr>
<td>Abnormal troponin I [n(%)]</td>
<td>93(37.50)</td>
<td>15(28.30)</td>
<td>1.606</td>
<td>0.205</td>
</tr>
<tr>
<td>Abnormal brain natriuretic peptide [n(%)]</td>
<td>49(19.76)</td>
<td>14(45.28)</td>
<td>1.169</td>
<td>0.280</td>
</tr>
<tr>
<td>Coronary heart disease specific index $\geq$ 4 points [n(%)]</td>
<td>18(7.26)</td>
<td>17(32.08)</td>
<td>26.173</td>
<td>0.001</td>
</tr>
<tr>
<td>Killip cardiac function class $\geq$ [n(%)]</td>
<td>98(39.52)</td>
<td>26(10.48)</td>
<td>1.641</td>
<td>0.200</td>
</tr>
<tr>
<td>Abnormal left ventricular ejection fraction [n(%)]</td>
<td>61(24.60)</td>
<td>30(56.60)</td>
<td>21.209</td>
<td>0.001</td>
</tr>
<tr>
<td>Hyperlipidemia [n(%)]</td>
<td>25(10.08)</td>
<td>22(41.51)</td>
<td>32.735</td>
<td>0.001</td>
</tr>
<tr>
<td>Multivessel disease [n(%)]</td>
<td></td>
<td></td>
<td>15.422</td>
<td>0.001</td>
</tr>
<tr>
<td>$\leq$ 1 stick</td>
<td>132(53.23)</td>
<td>17(32.08)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 3.2 Multivariate analysis of revascularization in patients with coronary heart disease after PCI

Taking the revascularization situation as the dependent variable and the statistically significant indicators in Table 1 as the independent variables, multivariate Logistic regression analysis was performed. The results showed that poor daily living behaviors, coronary heart disease specific index $\geq 4$ points, hyperlipidemia, and multivessel disease were the independent influencing factors of revascularization in patients with coronary heart disease after PCI (see Table 2).

#### Table 2
Multivariate Logistic regression analysis of repeat revascularization in patients with coronary heart disease after PCI

<table>
<thead>
<tr>
<th>independent variable</th>
<th>$\beta$</th>
<th>$SE$</th>
<th>Wald</th>
<th>$P$ value</th>
<th>OR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bad daily life behavior</td>
<td>1.437</td>
<td>0.425</td>
<td>11.416</td>
<td>0.001</td>
<td>4.208(1.828, 9.686)</td>
</tr>
<tr>
<td>Coronary heart disease specific index $\geq 4$ points</td>
<td>1.196</td>
<td>0.536</td>
<td>4.985</td>
<td>0.026</td>
<td>3.308(1.157, 9.453)</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>1.983</td>
<td>0.412</td>
<td>23.112</td>
<td>0.001</td>
<td>7.262(3.236, 16.296)</td>
</tr>
<tr>
<td>Multivessel disease: $\leq 1$ stick</td>
<td>-</td>
<td>-</td>
<td>15.421</td>
<td>0.001</td>
<td>-</td>
</tr>
<tr>
<td>Multivessel disease: 2 sticks</td>
<td>0.990</td>
<td>0.475</td>
<td>4.347</td>
<td>0.037</td>
<td>2.691(1.061, 6.822)</td>
</tr>
<tr>
<td>Multivessel disease: 3 sticks</td>
<td>1.803</td>
<td>0.459</td>
<td>15.417</td>
<td>0.001</td>
<td>6.068(2.467, 14.925)</td>
</tr>
<tr>
<td>constant</td>
<td>-3.623</td>
<td>0.442</td>
<td>67.241</td>
<td>0.001</td>
<td>-</td>
</tr>
</tbody>
</table>

#### 3.3 Establishment and internal validation of a nomogram model for the risk of repeat revascularization in patients with coronary heart disease after PCI

The independent risk factors of revascularization after PCI in patients with coronary heart disease were used as model inclusion variables to construct a model, and R software was used to draw a nomogram (see Fig. 1). The application of the Nomo map is as follows: Based on the Nomo map, a score corresponding to each risk factor can be obtained, and the scores of all risk factors are added up and
recorded as a total score. The predicted probability of the operation reconstruction. An ROC curve was drawn to internally validate the predictive performance of the model. The results showed that the AUC value was 0.830 [95%CI (0.782, 0.870), P < 0.05], the Youden index was 0.5530, the specificity was 85.48%, the sensitivity was 69.81%, and the cut-off value was 122.39 points (see Fig. 2). It suggests that the model has better predictive performance.

4 Discussion

4.1 The nomogram model of the risk of revascularization in patients with coronary heart disease after PCI is scientific and practical

In this study, a nomogram model of revascularization in patients with coronary heart disease after PCI was constructed and validated internally. The results show that the model has good predictive performance. This nomogram can help medical staff evaluate the risk factors of repeated revascularization in patients with coronary heart disease, activities of daily living, coronary heart disease-specific index, hyperlipidemia, and multivessel disease, and estimate the risk of repeated revascularization. It will help medical staff to further provide more precise, personalized and effective nursing interventions for patients.

4.2 Influencing factors of revascularization after PCI in patients with coronary heart disease

4.2.1 Patients with poor daily living behaviors are at greater risk of repeat revascularization

Bad daily life behaviors are closely related to the occurrence of coronary heart disease. Not only that, related studies have shown that poor life behaviors such as eating dinner, smoking, drinking, and irregular exercise are also closely related to revascularization in patients with coronary heart disease after PCI [8]. In this study, satiety at dinner, smoking, drinking, and irregular exercise were taken as relevant contents to assess whether patients had bad daily life behaviors. The results showed that coronary heart disease patients with poor daily living behaviors were more likely to have revascularization after PCI than patients with good daily living behaviors. It can be seen that the popularization of health education about daily life behavior is very important, not only for the general population. Patients with coronary heart disease and even those who have undergone related treatments such as PCI surgery need to correct their poor daily life behaviors to prevent recurrence.

4.2.2 The higher the coronary heart disease specific index, the greater the risk of repeat revascularization

Studies have shown that coronary heart disease patients with hypertension, diabetes and other diseases are closely related to revascularization after PCI [9]. Coronary heart disease patients with hypertension,
diabetes, and stroke often have more severe vascular lesions, which can damage the vascular endothelium and hyperactivity of platelets through inflammation and oxidative stress. This further promotes the formation of atherosclerosis and increases the risk of revascularization [10]. The coronary heart disease-specific index is an evaluation tool specially used to assess the severity of the underlying disease in patients with coronary heart disease. Compared with the common comorbidity index, this model is more targeted and has better predictive performance for the prognosis of patients with coronary heart disease [11]. The results of this study showed that the risk of revascularization in patients with coronary heart disease index ≥ 4 points, that is, high-risk patients, was 1.196 times that of patients with < 4 points. It is suggested that medical staff should strengthen the cooperation of multidisciplinary teams, pay attention to the management of underlying diseases of patients after PCI, actively treat reversible underlying diseases, and minimize the impact of patients' existing underlying diseases on the prognosis of revascularization.

4.2.3 Patients with hyperlipidemia have a higher risk of repeat revascularization

The results of this study showed that coronary heart disease patients with hyperlipidemia had a higher risk of repeat revascularization after PCI. Hyperlipidemia mainly refers to the abnormal fat metabolism or operation, which makes the blood lipid content in the human blood exceed the normal range, manifested as high blood cholesterol and (or) triglycerides or low high density lipoprotein. Previous studies have also shown that indicators that reflect blood lipid status, such as high-density lipoprotein, cholesterol, and triglycerides, are closely related to revascularization in patients with coronary heart disease after PCI [12, 13]. At present, statins are relatively mature for the control of blood lipids. Therefore, clinical medical staff should pay attention to the control of blood lipids in patients with coronary heart disease after PCI, and instruct them to follow the doctor's instructions to avoid blood vessel stenosis caused by improper blood lipid control.

4.2.4 Patients with multivessel disease are at greater risk of repeat revascularization

Relevant studies have shown that in patients with coronary heart disease, especially in patients with acute myocardial infarction, the incidence of multivessel disease can be as high as 40%-50% [14]. Multivessel disease has always been a difficult problem in interventional revascularization treatment, and there has been clinical controversy over whether patients with multivessel disease should undergo complete revascularization or selective partial revascularization [15]. Compared with other coronary heart disease patients, patients with multivessel disease often have a poor prognosis after PCI, and the risk of revascularization is also higher [16]. In this study, the diseased blood vessels of patients with coronary heart disease were investigated and analyzed, and it was found that the risk of revascularization after PCI in patients with coronary heart disease with 2-vessel lesions was 0.990 times that of patients with ≤ 1-vessel disease; patients with coronary heart disease with 3-vessel lesions underwent PCI. The risk of subsequent revascularization was 1.803 times that of patients with ≤ 1-vessel disease, suggesting that
patients with complex disease had a higher risk of repeat revascularization and a poorer prognosis. Therefore, clinical medical staff should choose appropriate treatment strategies for patients with complex vascular lesions, strengthen drug treatment and pay attention to patients' health education, so as to minimize the risk of revascularization and improve the prognosis of patients.

## 5 Conclusion

In this study, Logistic regression was used to analyze the independent risk factors of revascularization in patients with coronary heart disease after PCI, and on this basis, a nomogram model of revascularization in patients with coronary heart disease after PCI was constructed. The model has high predictive performance. It is helpful for medical staff to capture the risk information and risk factors related content of revascularization of patients in a timely manner, and provide a basis for formulating individualized and precise intervention plans. However, this study did not further conduct external validation and clinical application of the established model. Therefore, in the future, the model can be used to clinically assess the risk of revascularization after PCI in patients with coronary heart disease. Evaluate and formulate patient intervention strategies and conduct clinical empirical research.

### Declarations

**Data Availability**

The data used to support the findings of this study are available from the corresponding author upon request.

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

**Author’s Contributions**

Xuelian Zhou is mainly responsible for research design and thesis writing. Hongwei Yu is mainly responsible for research design and data analysis. Xiao Miao is mainly responsible for charting. Shaomin Wang is mainly responsible for the revision of papers and charts. Xiaobo Li is mainly responsible for data analysis. Liqun Zhu is mainly responsible for proofreading. Songmei Cao is mainly responsible for providing relevant data. Xuelian Zhou, Hongwei Yu and Liqun Zhu contributed equally to this work.

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References


**Figures**
Figure 1

Nummogram model of revascularization in patients with coronary heart disease after PCI
Figure 2

ROC curve of the nomogram model of revascularization in patients with coronary heart disease after PCI