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*Original Article*

# A risk predictive model for determining the severity of coronary artery lesions in older postmenopausal women with coronary heart disease

Wei Wen*, Qing Ye*, Li-Xiang Zhang*, Li-Kun Ma

*Department of Cardiology, The First Affiliated Hospital of USTC, Division of Life Sciences and Medicine, University of Science and Technology of China, Hefei 230001, Anhui, China. *Equal contributors.*

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**Abstract:** Objective: To determine the risk factors affecting the severity of coronary artery disease (CAD) in older postmenopausal women with coronary heart disease (CHD) and to construct a personalized risk predictive model. Methods: In this cohort study, clinical records of 527 female patients aged ≥60 with CHD who were hospitalized in the First Affiliated Hospital of the University of Science and Technology of China from March 2018 to February 2019 were analyzed retrospectively. The severity of CAD was determined using the Gensini scores that are based on coronary angiography findings. Patients with Gensini scores ≥40 and <40 were divided into high-risk (n=277) and non-high-risk groups (n=250), respectively. Logistic regression analysis was used to assess independent predictors of CAD severity. The nomogram prediction model of CAD severity was plotted by the R software. The area under the receiver operating characteristic (ROC) and calibration curves were used to evaluate the predictive efficiency of the nomogram model, and the decision curve analysis (DCA) was used to assess the clinical applicability of the nomogram model. Results: Multivariate analysis showed that high-sensitivity C-reactive protein, RBC count, WBC count, BMI, and diabetes mellitus were independent risk factors associated with CAD severity in older menopausal women (P<0.05); the area under the ROC curve of the nomogram constructed based on the independent risk factors was 0.846 (95% CI: 0.756-0.937). The area under the ROC curve after internal validation of the nomogram by the Bootstrap method after resampling 1000 times was 0.840 (95% CI: 0.741-0.923). The calibration curve suggested that the nomogram had an excellent predictive agreement, and the DCA curve indicated that the net benefit of applying the nomogram was significantly higher than that of the "no intervention" and "all intervention" methods when the risk probability of patients with high-risk CAD severity was 0.30-0.81. Conclusion: A personalized risk assessment model was constructed based on the risk factors of severe CAD in older menopausal women with CHD, which had good prediction efficiency based on discrimination, calibration, and clinical applicability evaluation indicators. This model could assist cardiology medical staff in screening older menopausal women with CHD who are at a high risk of severe CAD to implement targeted interventions.

**Keywords:** Older, female, coronary heart disease, coronary artery, severity of lesion, risk prediction, nomogram

## Introduction

Lifestyle modifications increase the exposure to cardiovascular risk factors, leading to a continuous increase in the incidence and mortality associated with cardiovascular diseases (CVDs). The incidence of coronary heart disease (CHD) in the female population is also increasing year by year [1]. According to the China Cardiovascular Health and Disease Report 2019, the age-standardized hospitalization rate of acute myocardial infarction (AMI) in Beijing increased by 31.2%, whereas in Central Africa, the non-ST-segment elevation myocardial infarction (NSTEMI) accounted for more than ST-segment elevation myocardial infarction in women. The incidence of asymptomatic AMI in women is high, leading to delayed treatment and affecting subsequent diagnosis and treatment [2]. Postmenopausal women have a higher risk of CHD due to declining estrogen levels [3]. In addition, Luo et al. divided 150 female patients with CHD into a premenopausal group (48 patients) and a postmenopausal group (102 patients). Based on estrogen levels and coronary angiography findings, the proportions

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of patients with unstable angina pectoris and myocardial infarction in the postmenopausal group were (59.80% and 37.25%, respectively), which was higher than those in the premenopausal group (37.50% and 18.75%, respectively).

Moreover, the estradiol levels in the postmenopausal group were (94.23±21.20 pmol/L) lower than that in the premenopausal group (243.85±60.41 pmol/L), and the difference was statistically significant (t=22.328, P< 0.001) [4]. The estrogen levels in postmenopausal patients with CHD decrease significantly, which weakens the protective effect of estrogen on the cardiovascular system and increases the risk of dyslipidemia, increases blood viscosity, and impairs vascular endothelial function, thus increasing the incidence of CHD in postmenopausal women. Therefore, menopause has become a novel risk factor for CHD in women. CHD seriously affects the health status and has become one of the leading causes of death in postmenopausal women. In addition, the risk of CHD in postmenopausal women is influenced by many factors, including but not limited to age, hypertension, neutrophil-lymphocyte ratio, triglyceride, and epicardial adipose tissue [5, 6]. Therefore, the related mechanism and risk factors of CHD in postmenopausal women deserve further study. The Gensini score can reflect the degree of coronary artery stenosis and diffusion [7, 8]. At present, studies on risk factors of coronary artery lesion severity in female patients with CHD mainly focus on screening of risk factors, especially in young and middle-aged female patients with CHD [9-11]. Limited studies have screened the risk of developing severe coronary artery lesions in older postmenopausal female patients with CHD. Based on this, our study integrated the risk factors associated with CAD severity in older menopausal women with CHD to construct a personalized risk assessment model and develop a new strategy for clinical early prevention of CHD in older women.

## Object and method

### *Subjects*

This retrospective cohort study included 527 female patients with CHD aged ≥60 years who attained menopause naturally and were hospitalized in the Department of Cardiology of the First Affiliated Hospital of the University of Science and Technology of China due to precordial discomfort and underwent coronary angiography. Inclusion criteria were as follows: (1) postmenopausal women with no history of menopause-related hormonal replacement therapy; (2) participants with a diagnosis of CHD confirmed by clinical evaluation and/or imaging tests fulfilling the diagnostic criteria for CHD; (3) subjects with complete clinical data; (4) subjects were postmenopausal women with menopause >1 year; (5) no contraindications to coronary angiography. Exclusion criteria were as follows: (1) patients whose clinical data is incomplete; (2) patients with prior coronary artery surgery or CHD; (3) individuals who are experiencing liver and kidney dysfunction, as well as those who have been diagnosed with rheumatic heart disease, valvular heart disease, and other types of heart conditions; (4) patients who are suffering from disorders affecting the blood, nerves, endocrine system, and immune system; (5) individuals who are currently dealing with both acute and chronic infections. The research protocol for this study was approved by the First Affiliated Hospital of the University of Science and Technology of China (2023-RE-051). The study was conducted following the ethical guidelines stated in the "Declaration of Helsinki". As this study relied on retrospective data and all data were anonymized, the requirement for obtaining informed consent from participants was waived.

### *Data collection method*

The general clinical data, including age, height, weight, hypertension, diabetes, and smoking history, were collected through the electronic medical record system. The methods for collecting blood specimens and laboratory indicators were as follows: 3-4 mL of fasting elbow venous blood was collected in the morning of the next day after admission and placed in an anticoagulant tube for inspection. Information on serum creatinine, fasting plasma glucose, glycosylated hemoglobin (HbA1c), alanine aminotransferase (ALT), aspartate aminotransferase (AST), HDL-C, LDL-C, TG, TC, estradiol, white blood cells, lymphocytes, monocytes, cardiac troponin I (cTnI), and high-sensitivity C-reactive protein (hs-CRP) levels were detected in the biochemical laboratory of the hospital and were

collected through the electronic medical record system.

*Gensini score*

More than two cardiologists performed coronary angiography. The Judkin's method was used to record the results of coronary angiography. The Gensini scores quantified the results of coronary angiography. The diagnostic standard of CHD was any coronary artery stenosis ≥50%. The Gensini score, which was used to reflect the severity of coronary artery lesions, was 1, 2, 4, 8, 16, and 32 points when the luminal stenosis was ≤25%, 26%-50%, 51%-75%, 76%-90%, 91%-99%, and 100%, respectively. Scores measured in each coronary artery: proximal, middle, distal and posterior descending branches of right coronary artery (RCA) ×1; left main lesions ×5; left circumflex artery (LCX) proximal segment ×2.5, middle segment ×1.5, distal segment and posterior descending artery both ×1, left ventricular posterior artery (PL) ×0.5; left anterior descending artery proximal segment ×2.5, middle segment ×1.5, distal segment ×1; a first diagonal branch (D1) ×1; the second diagonal branch (D2) ×0.5; the final Gensini score was the sum of the scores measured in each coronary artery. Patients with a Gensini score ≥40 were included in the high-risk group, and patients with a Gensini score <40 were included in the non-high-risk group [12].

*Statistical methods*

In this study, the R software (R 3.6.1) was used for data analysis. The measurement data were expressed by (mean ± standard deviation) and M (P25, P75) according to whether they obeyed normal distribution. The intergroup comparison was performed by independent sample t-test and Mann-Whitney U test. The categorical data were expressed by number of cases and percentage, and intergroup comparison was performed by an unadjusted Pearson chi-square test. The Lasso (Least absolute shrinkage and selection operator) regression method was used to screen the characteristic variables for the severity of CAD. The logistic regression analysis based on the results of the lasso regression method was used to screen the independent risk factors for the severity of CAD. The "rms" package in R software was used to construct the nomogram model and the calibration curve of the nomogram. The "pROC" package was used for plotting the ROC (receiver operating characteristic) curve. To prevent over-fitting of the nomogram, according to the internal validation protocol in the statement of "TRIPOD", the "caret" package was used to conduct the Bootstrap method (self-sampling 1000 times) for internal validation of the nomogram. The difference was considered statistically significant at $P<0.05$.

## Results

*Comparison of clinical data between high-risk and non-high-risk groups*

Between-group comparisons showed statistically significant differences in the distribution of 14 variables, including diabetes, FT3, HbA1c, postprandial blood glucose, fasting blood glucose, random blood glucose, cystatin C, hs-CRP, Hb, RBC, lymphocyte percentage, neutrophil percentage, white blood cell count and BMI (all $P<0.05$). As shown in **Table 1**.

*Lasso regression method for screening of characteristic variables of severity of coronary artery lesions in older postmenopausal women with CHD*

Considering that there are many potential risk indicators screened from the results of univariate analysis from **Table 1**, the Lasso regression method was used to reduce the dimension of the 14 risk factors with statistically significant differences ($P<0.05$) screened in **Table 1** to screen out further the characteristic variables affecting the severity of coronary artery lesions. Adopt 10-fold cross-validation, take the Lambda value (λ value) at the standard error of the minimum distance as the optimal solution of the model, and make statistics on the variable name and number of the corresponding non-zero regression coefficient at this time. The Lasso regression results showed that the Lambda value of the standard error of minimum distance was 0.038, and the variables of the corresponding model were selected as diabetes, BMI, WBC count, RBC count, hs-CRP, and cystatin (**Figure 1**).

*Multivariate regression analysis of severity of CAD in older postmenopausal women*

The six characteristic variables screened by the Lasso regression method were used as inde-

**Table 1.** Comparison of clinical data between the two groups

| Variables | Total (n=527) | Non-high risk group (n=250) | High risk group (n=277) | Statistic | P |
|---|---|---|---|---|---|
| Educational level, n (%) | | | | 2.030[a] | 0.362 |
| Junior high school and below | 473 (89.75) | 220 (88.00) | 253 (91.34) | | |
| Senior high school and technical secondary school | 38 (7.21) | 20 (8.00) | 18 (6.50) | | |
| College degree or above | 16 (3.04) | 10 (4.00) | 6 (2.17) | | |
| History of cerebrovascular disease, n (%) | | | | 0.053[a] | 0.817 |
| No | 396 (75.14) | 189 (75.60) | 207 (74.73) | | |
| Yes | 131 (24.86) | 61 (24.40) | 70 (25.27) | | |
| Concomitant hypertension, n (%) | | | | 0.070[a] | 0.792 |
| No | 151 (28.65) | 73 (29.20) | 78 (28.16) | | |
| Yes | 376 (71.35) | 177 (70.80) | 199 (71.84) | | |
| Concomitant diabetes, n (%) | | | | 9.689[a] | 0.002 |
| No | 337 (63.95) | 177 (70.80) | 160 (57.76) | | |
| Yes | 190 (36.05) | 73 (29.20) | 117 (42.24) | | |
| TSH | 2.43 (1.60, 3.84) | 2.45 (1.60, 3.86) | 2.38 (1.61, 3.84) | 0.175[b] | 0.861 |
| FT4 | 12.64 (11.43, 14.02) | 12.67 (11.60, 14.08) | 12.45 (11.27, 14.00) | 1.019[b] | 0.308 |
| FT3 | 4.48 (3.96, 4.89) | 4.54 (4.09, 4.99) | 4.45 (3.91, 4.82) | 2.806[b] | 0.005 |
| VLDL-C | 1.07 (0.88, 1.33) | 1.12 (0.90, 1.38) | 1.05 (0.86, 1.30) | 1.944[b] | 0.052 |
| LDL-C | 2.20 (1.72, 2.70) | 2.19 (1.69, 2.77) | 2.21 (1.76, 2.66) | 0.094[b] | 0.926 |
| HDL-C | 0.99 (0.85, 1.16) | 0.99 (0.85, 1.20) | 0.99 (0.83, 1.13) | 1.078[b] | 0.281 |
| Triglyceride | 1.56 (1.16, 2.08) | 1.54 (1.16, 2.09) | 1.58 (1.15, 2.05) | 0.333[b] | 0.739 |
| Total cholesterol | 4.30 (3.68, 4.98) | 4.38 (3.62, 5.13) | 4.25 (3.72, 4.85) | 1.143[b] | 0.253 |
| HbA1c | 6.20 (5.80, 7.10) | 6.00 (5.80, 6.90) | 6.20 (5.90, 7.30) | -2.379[b] | 0.017 |
| Postprandial blood glucose | 8.60 (7.48, 12.11) | 7.98 (7.25, 11.11) | 8.80 (7.68, 12.56) | -2.742[b] | 0.006 |
| Fasting blood glucose | 5.28 (4.75, 6.45) | 5.18 (4.69, 6.11) | 5.39 (4.75, 6.68) | -2.080[b] | 0.038 |
| Random blood glucose | 7.02 (5.62, 9.52) | 6.65 (5.47, 8.77) | 7.41 (5.75, 9.89) | -2.596[b] | 0.009 |
| Cystatin | 0.93 (0.82, 1.11) | 0.90 (0.80, 1.07) | 0.96 (0.83, 1.14) | -2.565[b] | 0.01 |
| Uric acid | 306.00 (247.00, 370.00) | 302.00 (246.00, 360.00) | 312.00 (250.00, 375.00) | -0.402[b] | 0.688 |
| Creatinine | 62.00 (53.00, 76.00) | 61.00 (52.00, 75.00) | 64.00 (54.20, 79.00) | -1.873[b] | 0.061 |
| Urea nitrogen | 6.34 (5.08, 7.98) | 6.29 (5.06, 7.85) | 6.46 (5.11, 8.10) | -0.923[b] | 0.356 |
| Serum albumin | 43.20 (40.20, 45.60) | 43.80 (40.20, 45.90) | 42.70 (40.00, 45.50) | 1.536[b] | 0.125 |
| AST | 20.00 (16.00, 28.00) | 20.00 (16.00, 27.00) | 20.00 (17.00, 31.00) | -1.242[b] | 0.214 |
| ALT | 17.00 (13.00, 26.00) | 17.00 (13.00, 24.00) | 18.00 (13.00, 28.00) | -1.733[b] | 0.083 |
| hs-CRP | 4.15 (1.76, 5.00) | 3.46 (1.45, 5.00) | 4.88 (2.30, 5.00) | -3.940[b] | <0.001 |
| PLT | 196.00 (162.00, 233.00) | 194.00 (162.00, 230.00) | 202.00 (162.00, 239.00) | -1.200[b] | 0.23 |
| Hb | 119.00 (110.00, 126.00) | 120.00 (112.00, 128.00) | 117.00 (106.00, 125.00) | 3.201[b] | 0.001 |
| RBC | 3.87 (3.60, 4.18) | 3.95 (3.69, 4.21) | 3.82 (3.48, 4.14) | 3.631[b] | <0.001 |
| Lymphocyte percentage | 27.77±8.82 | 28.75±8.56 | 26.88±8.94 | 2.453[c] | 0.015 |
| Neutrophil percentage | 62.90 (56.50, 69.10) | 61.80 (55.40, 67.60) | 64.00 (57.40, 70.30) | -2.469[b] | 0.014 |
| White blood cell count | 6.15 (5.30, 7.69) | 6.04 (5.18, 7.12) | 6.43 (5.40, 8.05) | -2.421[b] | 0.016 |
| Average Daily Sleep Duration | 6.00 (6.00, 7.00) | 6.00 (6.00, 7.00) | 6.00 (6.00, 7.00) | -0.610[b] | 0.514 |
| BMI | 24.44 (22.67, 26.91) | 24.97 (23.05, 27.18) | 24.14 (22.27, 26.40) | 2.702[b] | 0.007 |
| Age | 69.00 (65.00, 74.00) | 69.00 (65.00, 74.00) | 70.00 (65.00, 75.00) | -1.151[b] | 0.249 |

Note: a. Pearson Chi-square test, b. Mann-Whitney rank sum test, c. Independent sample t-test.

pendent variables, and the severity of coronary artery lesions (high-risk group =1, non-high-risk group =0) was used as the dependent variable to perform multivariate regression analysis. The variables were screened by the backward method. The results of multivariate regression analysis showed that hs-CRP, RBC, WBC count, BMI, and diabetes mellitus were independent risk factors for CAD severity in older menopausal women (P<0.05) (**Table 2**).

*Construction of the nomogram prediction model*

According to the results of multivariate Logistic regression analysis, the "rms" package of R software was used to construct the nomogram model of severity of coronary artery lesions in older menopausal women with CHD, as shown in **Figure 2**. The interpretation of the nomogram is that the specific value of each index on the

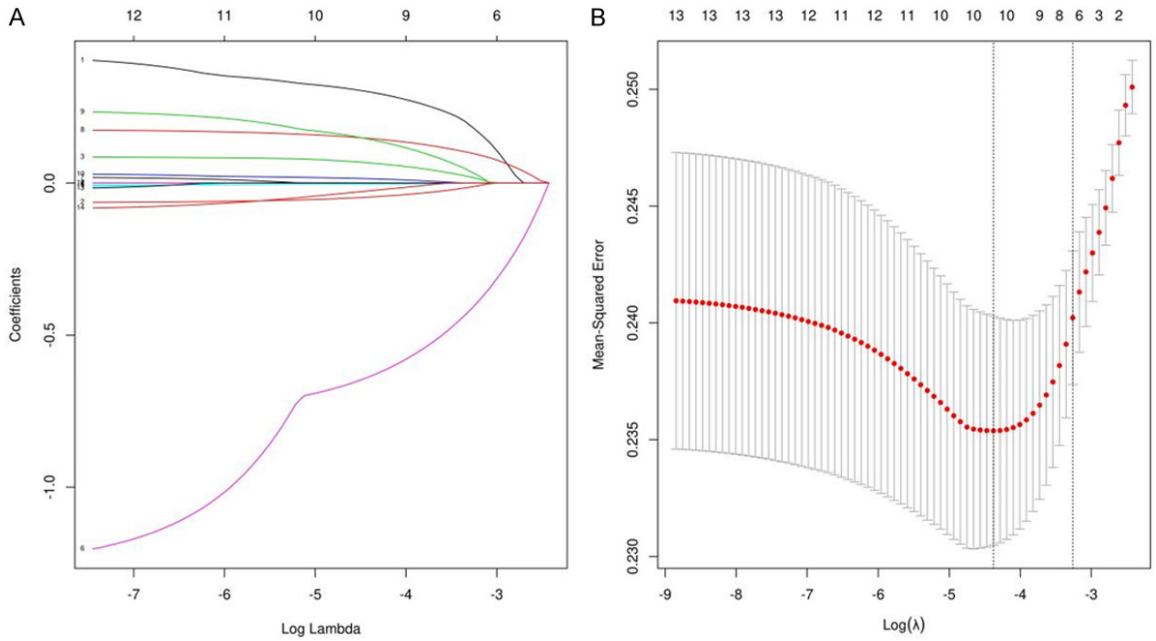


**Figure 1.** LASSO regression results for 14 risk variables. Note: (A) Coefficient path diagram of risk variables; (B) Cross-validation curves for LASSO regression. The λ of the least mean square error was 0.013, and the corresponding variables were: diabetes + BMI + WBC + neutrophil + lymphocyte + RBC + hs-CRP + cystatin + random blood glucose + FT3; The λ of the standard error of the minimum distance was 0.038, and the corresponding model variables were diabetes + BMI + WBC + RBC + hs-CRP + cystatin.

**Table 2.** Results of multivariate regression analysis of severity of coronary artery lesions

| Indicators | β | SE | Z | P | OR | 95% CI of OR |
|---|---|---|---|---|---|---|
| Constant | 3.461 | 1.025 | 3.377 | 0.001 | - | - |
| hs-CRP | 0.176 | 0.053 | 3.296 | 0.001 | 1.192 | 1.075-1.325 |
| RBC | -0.831 | 0.213 | -3.908 | 0.000 | 0.436 | 0.285-0.657 |
| White blood cell count | 0.112 | 0.046 | 2.436 | 0.015 | 1.118 | 1.024-1.227 |
| BMI | -0.067 | 0.029 | -2.282 | 0.022 | 0.936 | 0.883-0.990 |
| Concomitant diabetes mellitus | 0.474 | 0.194 | 2.446 | 0.014 | 1.606 | 1.100-2.353 |

horizontal axis in the nomogram is made a vertical line upward, corresponding to a particular score on the "Points"; the total score is obtained by adding the scores obtained from the five indicators. The total score corresponds to the specific value on the "Total Points" and makes a vertical line downward. The value on the horizontal axis of "Risk" is determined as the high risk of developing severe CAD in a patient.

*Internal validation and prediction efficiency analysis of the nomogram model*

The ROC curve of the nomogram was plotted using the "pROC" package of R software, and the area under the ROC curve ($AUC_{ROC}$) was 0.846 (95% CI: 0.756-0.937), as shown in **Figure 3**. The AUC of the ROC curve indicated that the nomogram model has good discrimination. To prevent over-fitting of the nomograms, the nomograms were internally validated using Bootstrap self-sampling 1000 times and the AUC of the ROC curve of the nomogram after internal validation was 0.840 (95% CI: 0.741-0.923). The calibration curve after internal validation showed that the deviation correction curve of the nomogram was close to the ideal curve, and the mean absolute error between the predicted probability and the actual occurrence frequency was 0.016, indicating that the nomogram had good prediction stability and prediction consistency. As shown in **Figure 4**.

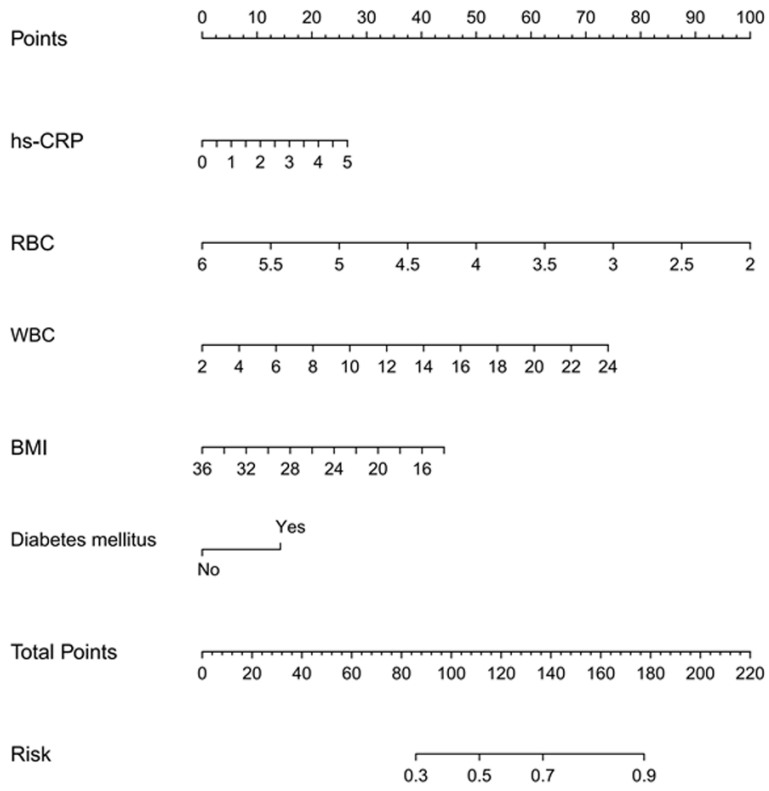


**Figure 2.** Nomogram model of coronary lesion severity.

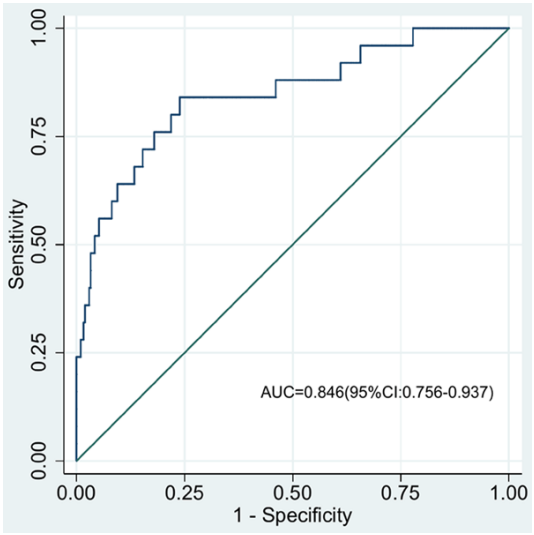


**Figure 3.** ROC curve for the nomogram model.

*Analysis of clinical applicability of nomogram model*

The DCA (decision curve analysis) curve of the nomogram model was constructed by taking the predictive probability of the nomogram as the test variable and the severity of coronary artery lesions of the patient as the state variable. As shown in **Figure 5**, when the threshold probability of the severity of coronary artery lesions in patients is at high risk, the threshold is 0.30-0.81, and the net benefit level of nomogram is significantly higher than that of "None" intervention and "All" intervention schemes, indicating that nomogram has good clinical applicability.

## Discussion

Premenopausal women have a lower prevalence of CHD due to the protective effect of estrogen on the cardiovascular system [13]. Metabolic functions in women significantly change during perimenopause because of decreased estrogen levels that disrupt the balance between glucose and lipid metabolism, thereby increasing the risk of diabetes mellitus and CVD [14, 15]. Furthermore, CHD is a prevalent type of CVD and serves as the fundamental cause of other CVDs. Therefore, to improve the health of older women, it is imperative to develop strategies for the prevention and treatment of CHD in perimenopausal women [16, 17]. Because of atypical symptoms, faster disease onset, high incidence rates, and poor prognosis associated with premature CHD in female patients, immediate management is crucial. Currently, the detection and treatment strategies for CHD are insufficient for the above reasons [18]. The Gensini score was proposed in 1983 [19] to evaluate the severity of coronary artery lesions based on the location, degree of stenosis, and number of lesions in coronary angiography findings. It is widely used in clinical practice and scientific research. In the past, CHD was thought to occur frequently in the older population, and the research was mainly aimed at the older. Recent national and international studies have primarily focused on male patients with CHD. In contrast, the studies on perimenopaus-

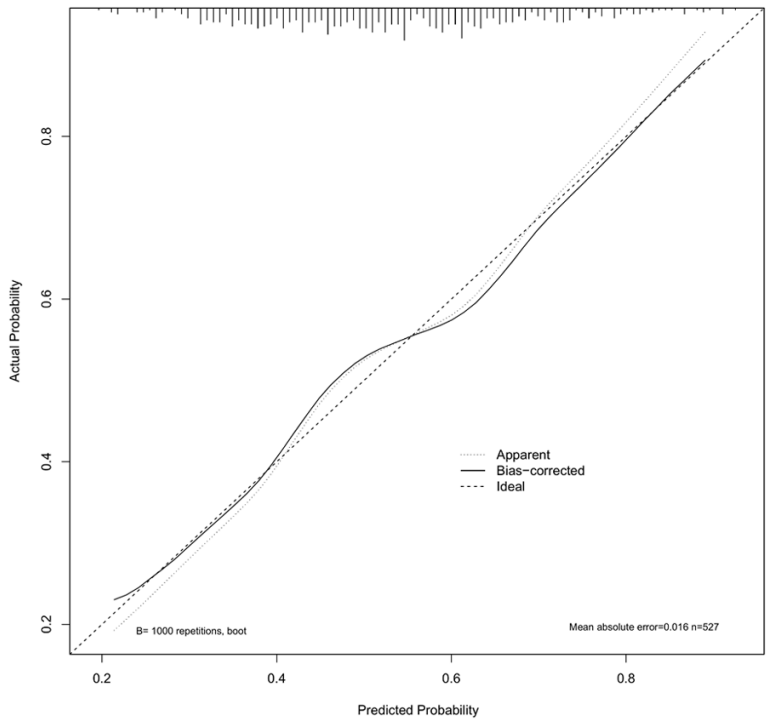


**Figure 4.** Calibration curve of the nomogram model.

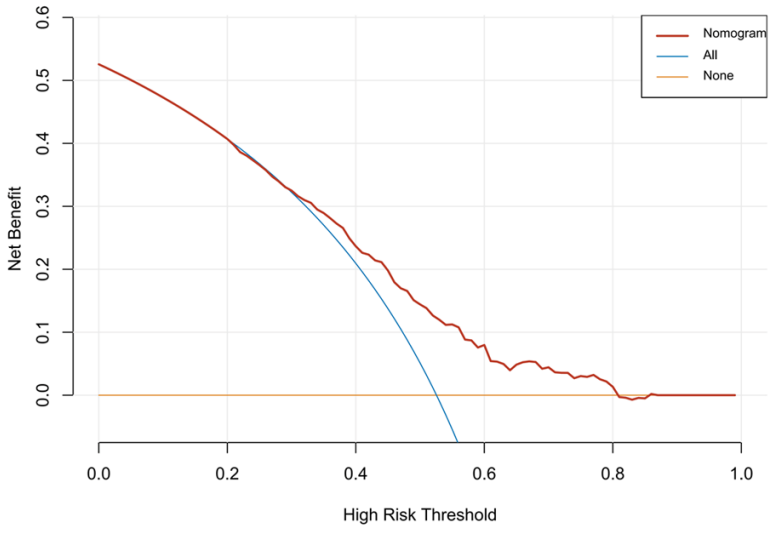


**Figure 5.** Clinical decision analysis curves for the nomogram.

al women with premature CHD are few, especially those evaluating the risk factors associated with the disease severity in women with premature CAD [11]. This study aimed to analyze the risk factors associated with severe CAD in older perimenopausal women with CHD, to construct a personalized risk assessment model, and to provide a reference for clinical prevention, diagnosis, and treatment.

Xu et al. [20] reported that hs-CRP is an independent risk factor affecting the disease severity in perimenopausal female patients with CHD, which was consistent with the results of this study, which showed hs-CRP to be an independent risk factor for severe CAD in older menopausal women ($P<0.05$). Atherosclerosis is a chronic inflammatory disease [21], and hs-CRP is a common inflammatory factor associated with atherosclerosis severity. Under the stimulation of inflammatory factors such as interleukin-6, the hs-CRP levels increase significantly. The higher the level, the worse the stability of coronary atherosclerotic plaque and the more severe the disease [22]. Insulin resistance in patients with CHD is positively correlated with CAD, suggesting that effective glycemic control may be an essential measure to delay the progression of CAD and prevent adverse cardiovascular events [23]. This is consistent with the finding of this study that diabetes mellitus is an independent risk factor for CHD severity in older menopausal women ($P<0.05$). The study by Cui et al. [24] found that BMI can reflect CAD severity in patients with CHD to some extent, which is consistent with the finding of this study that BMI is an independent risk factor for CHD severity in older menopausal women ($P<0.05$). As one of the recognized indicators of inflammation, WBCs play a vital role in atherosclerosis and progression. Moreover, increased white blood cell counts reflect the inflammatory state, which may directly lead to atherosclerosis through specific mechanisms and be related to vascular dys-

function [25]. Epidemiological studies have shown that white blood cell count is positively correlated with CVD risk in healthy people without CVD and in patients with CVD, and total white blood cell count is independently correlated with the presence of coronary atherosclerotic plaque and the severity of stenosis [26]. This is consistent with the findings that white blood cell count is an independent risk factor for the severity of CHD in older menopausal women ($P<0.05$). The dynamic observation of red blood cell parameters after myocardial infarction in related literature shows that the red blood cell count will decrease after AMI, which suggests that the prognosis is poor, especially in women with acute heart failure or chronic kidney disease [27]. This is consistent with the result of this study that the decrease in red blood cell count is an independent risk factor for CAD severity in older menopausal women.

A nomogram is a graph with high and low line segments of scores based on multiple clinical indicators and multi-factor regression analysis, which is used to predict specific clinical outcomes or incidences of adverse events. It is more concise and accurate in quantifying risks [28]. Domestic studies have confirmed that nomograms have a good application effect in predicting the risk of CHD [29, 30] and the risk of ventricular arrhythmia after PCI [31]. However, there is no study on the risk assessment of CAD severity in older menopausal women with CHD in China. In this study, five independent coronary artery lesion severity predictors were screened out through multivariate Logistic regression, and a personalized nomogram model for high-risk prediction of coronary artery lesion severity was constructed based on these five independent predictors. The AUC of this nomogram model was 0.846 (95% CI: 0.756-0.937), and the AUC of the nomogram after internal validation was 0.840 (95% CI: 0.741-0.923), indicating that the nomogram has high discrimination ability. The calibration curve suggested that the occurrence risk predicted by the nomogram was in good agreement with the current value, and the nomogram model had good calibration.

Limitations of this study are as follows: (1) this single-center, retrospective study had a limited sample size, and the results may not apply to other populations. Therefore, a multi-center large-sample prospective study is warranted in the future to improve the accuracy of the prediction model and clinical applicability; (2) in this study, the constructed nomogram model underwent internal validation only, which necessitates the extrapolation of the model still through external validation in other clinical study centers to verify the prediction effect of nomogram; and (3) the predictive factors in the prediction model constructed in this study are limited, and it is of great practical significance to further incorporate more predictive risk assessment indicators to improve the prediction effect of the model.

## Conclusion

Based on the above discussion, the nomogram model constructed by integrating the five risk factors of severe CHD, including diabetes mellitus, WBC count, RBC count, hs-CRP, and BMI, has high prediction accuracy in screening older menopausal women at increased risk of severe CHD. Moreover, this nomogram prediction is more intuitive and individualized, with strong clinical application value.

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## Disclosure of conflict of interest

None.

**Address correspondence to:** Li-Kun Ma, Department of Cardiology, The First Affiliated Hospital of USTC, Division of Life Sciences and Medicine, University of Science and Technology of China, No. 1, Swan Lake Road, Hefei 230001, Anhui, China. E-mail: Lkma119@163.com

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