

Construction and Multicenter Validation of a Nomogram for Predicting 1-Year Target Vessel Revascularization After Percutaneous Coronary Intervention Based on Combined Clinical and Nursing Indicators

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Abstract

Background

Target vessel revascularization (TVR) is a common adverse event within 1 year after percutaneous coronary intervention (PCI) that significantly affects patient prognosis. Existing prediction models are largely limited to clinical indicators and do not include modifiable nursing and rehabilitation-related factors. This study aimed to develop and validate a nomogram incorporating both clinical and nursing indicators to predict TVR risk within 1 year after PCI, providing a basis for individualized risk assessment and intervention.

Methods

The data of 482 patients who underwent PCI at Peking University Third Hospital between January 2024 and June 2025 and who completed 1-year angiographic follow-up were retrospectively analyzed. The patients were divided into two groups based on the presence ($n = 55$ [11.4%]) or absence ($n = 427$ [88.6%]) of TVR. Independent predictors were identified through univariable analysis, least absolute shrinkage and selection operator regression, and multivariable logistic regression, and a nomogram model was constructed. Model performance was evaluated using receiver operating characteristic (ROC) curves, calibration curves, and decision curve analysis (DCA), with further validation in a multicenter external validation cohort.

Results

Thrombus (odds ratio [OR] 3.888), degree of calcification (OR 3.272), stent diameter (OR 0.378), Pittsburgh Sleep Quality Index (PSQI) score (OR 0.296), and Medication Adherence Rating Scale (MARS-5) score (OR 0.463) were independent predictors of 1-year TVR after PCI. The regression equation was $\text{Logit}(P) = -0.8407 + 1.3579 \times \text{thrombus} + 1.1854 \times \text{calcification} - 0.9729 \times \text{stent diameter} - 1.2174 \times \text{PSQI} - 0.7700 \times \text{MARS-5}$. The nomogram demonstrated strong discriminative ability, with area under the ROC curve values of 0.843 (95% confidence interval [CI] 0.782–0.901) in the derivation cohort and 0.819 (95% CI 0.749–0.886) in the external validation cohort. Calibration curves showed good agreement between the predicted and observed outcomes, and DCA confirmed significant clinical net benefit of the model.

Conclusions

The nomogram developed in this study integrates key clinical and nursing rehabilitation indicators, demonstrating excellent predictive performance and stability. The model is simple and practical,

enabling precise postoperative risk stratification and providing a scientific basis for individualized nursing interventions, such as sleep management and medication adherence.

Background

Coronary artery disease is a leading cause of mortality and disability worldwide, and percutaneous coronary intervention (PCI) remains the cornerstone treatment for this condition¹. Although advances in drug-eluting stent technology have significantly reduced the in-stent restenosis rate, the incidence of target vessel revascularization (TVR) within 1 year after PCI remains between 6.85% and 12%^{2,3}. This increases patient suffering and economic burden, as well as impairing long-term quality of life⁴. TVR is defined as any repeat revascularization of any segment of the target vessel initially treated, including the target lesion, its proximal and distal main branches, and all side branches, due to restenosis, thrombosis, or other causes⁵. Developing accurate early warning tools to identify patients at high risk of TVR is of great importance for optimizing clinical decision making and implementing individualized interventions.

Existing risk assessment tools have several limitations in clinical nursing practice. First, there is a mismatch in the time dimension. Most current models, both domestically and internationally, focus on predicting long-term (2–5-year) major adverse cardiovascular events, lacking models specifically targeting the critical 1-year post-PCI window for TVR^{6,7}. Second, existing models primarily emphasize non-modifiable clinical indicators, such as lesion characteristics, procedural factors, and comorbidities, while overlooking nursing and rehabilitation-related factors closely associated with patient outcomes, such as sleep quality, physical activity, and medication adherence^{8–10}. Third, machine learning models are often difficult to interpret and lack intuitive visualization, limiting their applicability and widespread use, particularly in primary healthcare settings¹¹.

This study aimed to integrate clinical indicators with nursing and rehabilitation management variables to develop a nomogram for predicting TVR risk within 1 year after PCI, followed by external validation using multicenter data. This study sought to provide a scientifically robust and user-friendly risk assessment tool for cardiovascular nursing teams, enabling precise risk stratification and individualized nursing intervention.

Methods

Participants

This retrospective cohort study included patients who underwent stent implantation at Peking University Third Hospital between January 2024 and June 2025 and who completed 1-year coronary angiographic follow-up. Data were obtained from the hospital's Electronic Medical Record system and the Research Platform for Cardiovascular Disease Quality Improvement. An additional 240 patients from Beijing Chaoyang Hospital affiliated with Capital Medical University, the Second Affiliated Hospital of Zhejiang

University School of Medicine, and Peking University Third Hospital were selected as the external validation cohort.

Inclusion Criteria

The inclusion criteria were as follows: (1) first successful implantation of everolimus- or zotarolimus-eluting stents at our institution, with residual stenosis $\leq 30\%$ after the procedure; (2) for patients who underwent multiple revascularization procedures, only the first two consecutive procedures with complete clinical data were included; and (3) complete and traceable clinical records.

Exclusion Criteria

The exclusion criteria were (1) patients scheduled for staged PCI; (2) patients with comorbid psychiatric disorders that could affect treatment adherence and clinical follow-up; (3) missing key variables or loss to follow-up; and (4) revascularization due to non-target vessel lesions.

Sample Size and Measurements

Variables

General characteristics included age, sex, body mass index, history of hypertension, diabetes mellitus, hyperlipidemia, smoking, and alcohol consumption. Laboratory data (abbreviated as Lab1) were obtained within 24 hours of the first hospital admission for all patients. For the case group, laboratory data at the time of repeat intervention were collected (abbreviated as Lab2). For the control group, laboratory results from the 1-year follow-up were recorded (abbreviated as Lab2). Lipid profiles included low-density lipoprotein cholesterol, high-density lipoprotein cholesterol (HDL-C), non-HDL-C to HDL-C ratio, and non-HDL-C. Renal function was assessed using serum creatinine (Cr). Hematological parameters included glycated hemoglobin (HbA1c), platelet count, and platelet aggregation rates induced by adenosine diphosphate and arachidonic acid. Meanwhile, the differences between the above two sets of hematological parameters were recorded, denoted by delta (Δ).

Procedural characteristics included stent diameter; stent length; total stent length; use of rotational atherectomy, intravascular lithotripsy balloon, or cutting balloon; presence of thrombus; target vessel for stent implantation; lesion type (simple, left main, bifurcation, or ostial lesion); use of intravascular imaging (intravascular ultrasound/optical coherence tomography); and degree of coronary artery calcification (none, mild, moderate, severe).

Nursing and rehabilitation indicators include antiplatelet therapy regimen, Pittsburgh Sleep Quality Index (PSQI), International Physical Activity Questionnaire (IPAQ) score, Medication Adherence Rating Scale (MARS-5), and Nutritional Risk Screening 2002 (NRS-2002).

Measurements

Smoking was defined as smoking ≥ 5 cigarettes per day for at least 1 year. **Alcohol consumption** was defined as daily intake of ≥ 100 g of liquor or ≥ 1000 mL of beer for at least 1 year. **The degree of calcification was** assessed visually by coronary angiography. No calcification was defined as the absence of obvious high-density shadows; mild calcification as calcification visible only under fluoroscopy during the cardiac cycle; moderate calcification as calcification visible on static angiographic images; and severe calcification as calcification involving both sides of the vessel wall or circumferential calcification¹². **The PSQI was** used to assess sleep quality over the previous month. The scale includes 19 self-rated items and 5 clinician-rated items, of which 18 items are grouped into 7 component scores. Each component is scored from 0 to 3. The sum of these component scores yields a global PSQI score ranging from 0 to 21, with 0–5 indicating good sleep quality, 6–11 indicating moderate sleep quality, and 12–21 indicating poor sleep quality¹³. **The IPAQ was** used to assess physical activity over the past 7 days, expressed as metabolic equivalent minutes per week (MET-min/week). MET values were assigned as follows: walking = 3.3, moderate-intensity activity = 4.0, and vigorous-intensity activity = 8.0. Total weekly physical activity was calculated as MET $\times$ days per week $\times$ minutes per day. The classification criteria were as follows: <600 MET-min/week indicates low physical activity, 600–3,000 MET-min/week indicates moderate physical activity, and $\geq 3,000$ MET-min/week indicates high physical activity¹⁴. The **MARS-5** consists of five items assessing patients' medication-taking behavior over a recent period and was used to evaluate post-PCI medication adherence. The scoring criteria were as follows: ≤ 10 indicates good adherence, 11–19 indicates moderate adherence, and >20 indicates poor adherence¹⁵. The NRS-2002 combines the intake ratios of total fat, protein, and carbohydrates, as well as food quality. The scale ranges from 0 to 30 points and reflects the overall high-fat dietary pattern¹⁶.

Statistical Analysis

Statistical analyses were performed using SPSS (version 26.0) and R (version 4.3.2). The normality of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed continuous variables are expressed as the mean $\pm$ standard deviation ($\bar{x} \pm s$) and were compared using the independent-samples t-test. Non-normally distributed continuous variables are expressed as the median with interquartile range [M (Q1, Q3)] and were compared using the Mann–Whitney U test. Categorical variables are presented as frequency and percentage (n, %) and were compared using the χ^2 test or Fisher's exact test. Ordinal variables were analyzed using the Mann–Whitney U test. For variables with a missing rate of $<10\%$, multiple imputation was applied to reduce potential bias. To prevent model overfitting, least absolute shrinkage and selection operator (LASSO) regression was first used with 10-fold cross-validation to identify features with non-zero coefficients. These variables were subsequently entered into the multivariable logistic regression model to determine independent predictors of 1-year TVR after PCI ($P < 0.05$). A nomogram model was constructed using the rms package. In both the derivation cohort and the multicenter external validation cohort, the discriminatory ability of the predictive model was evaluated using receiver operating characteristic (ROC) curves. Calibration curves and the Hosmer–Lemeshow goodness-of-fit test were used to assess the agreement between the

predicted probabilities and the actual observed probabilities. Decision curve analysis (DCA) was performed to evaluate the clinical net benefit of the model across different threshold probabilities.

Sample Size Calculation

The sample size was estimated using the following formula: $N \geq (10 \times X) \div P$. The number of events per candidate predictor in the model was set to ≥ 10 , X represents the number of candidate predictors (4–6 in this study), and P denotes the incidence of the study outcome (TVR). Based on the reported incidence of TVR within 1 year after PCI (6.85%–12.00%)^{2,3}, the minimum required sample size for model development was estimated to be 417 patients. Ultimately, 482 patients were included in the derivation cohort.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. It was approved by the Ethics Committee of Peking University Third Hospital (Approval No: M20250715). The requirement for informed consent was waived due to the retrospective observational nature of the study. All personal data were anonymized and securely stored, and used solely for scientific research purposes.

Results

Baseline Characteristics

Overall, 482 patients who underwent PCI and completed coronary angiographic follow-up within 1 year were included. Among them, 55 patients (11.4%) experienced TVR, while 427 patients (88.6%) did not.

univariable Analysis

The univariable analysis results showed that age, Δ Cr, HbA1c₂, stent diameter, thrombus formation, simple lesions, left main lesions, ostial lesions, antiplatelet therapy strategy, presence of calcification, PSQI, and MARS-5 were significant factors associated with the occurrence of TVR within 1 year after PCI (Table 1).

LASSO Regression

To avoid multicollinearity and achieve feature reduction, 12 variables with $P < 0.05$ in the univariable analysis were included in the LASSO regression model. Using 10-fold cross-validation, the optimal penalty parameter ($\lambda = 2.6561$) corresponding to the minimum binomial deviance was selected. As λ increased, the coefficients of the variables gradually decreased toward zero (Fig. 1a). At the optimal λ (Fig. 1b), 11 variables with non-zero coefficients were retained and subsequently entered into the multivariable logistic regression model. These variables included age, Δ Cr, postoperative HbA1c, stent diameter, thrombus, calcification, simple lesions, left main lesions, antiplatelet therapy strategy, PSQI, and MARS-5.

Multivariable Logistic Regression

The occurrence of TVR was set as the dependent variable, and the 11 variables identified above were included as independent variables in the multivariable logistic regression analysis. The results showed that stent diameter, thrombus, calcification, PSQI, and MARS-5 were independent predictors of TVR within 1 year after PCI ($P < 0.05$) (Table 2, Figure 2). The final regression equation for predicting TVR risk was as follows: $\text{Logit}(P) = -0.8407 + [\text{thrombus (yes = 1, no = 0)}] \times 1.3579 + [\text{calcification (none = 0, mild = 1, moderate = 2, severe = 3)}] \times 1.1854 - [\text{stent diameter (continuous value)}] \times 0.9729 - [\text{PSQI (low = 0, moderate = 1, high = 2)}] \times 1.2177 - [\text{MARS-5 (poor = 0, moderate = 1, good = 2)}] \times 0.7690$.

Nomogram Construction and Multicenter Validation

Based on the results of the multivariable regression analysis, a nomogram prediction model was constructed using R (version 3.6.3) (Fig. 3). The nomogram visually assigned a score to each predictor, and the total score was calculated by summing the individual scores to estimate the probability of TVR in patients who underwent PCI. The area under the ROC curve was 0.843 (95% confidence interval [CI] 0.782–0.901) in the derivation cohort (Fig. 4a) and 0.819 (95% CI 0.749–0.886) in the validation cohort (Fig. 4b), indicating good predictive accuracy. The calibration curve showed good agreement with the ideal curve, with a Brier score of 0.071 (Fig. 5a). DCA (Fig. 5b) demonstrated that the model provided high clinical net benefit across a wide range of threshold probabilities.

Discussion

Main Findings

This study successfully developed and externally validated a nomogram for predicting TVR risk within 1 year after PCI. The results demonstrated that the complexity of the initial lesion—particularly the presence of intracoronary thrombus and calcification—served as an independent risk factor for TVR; by contrast, patient health management and optimization of procedural strategies acted as key protective factors. By incorporating nursing and rehabilitation indicators, such as PSQI and MARS-5, in addition to traditional clinical variables, the predictive performance of the model was significantly improved. Moreover, the model maintained stable performance after external validation, indicating good generalizability. These findings provide an objective basis for clinical nursing staff to identify high-risk patients and develop precise cardiac rehabilitation strategies.

Impact of Lesion Anatomical Characteristics on TVR: Challenges of Lesion Complexity

This study confirmed that patients with intracoronary thrombus had a 3.89-fold higher risk of TVR than those without thrombus, indicating that thrombus burden was associated with a higher likelihood of restenosis after PCI, consistent with previous studies^{17,18}. Thrombus not only contributes to intraoperative no-reflow or distal embolization, but it also promotes intimal hyperplasia and vascular remodeling through local inflammatory mediator release during thrombus organization^{19,20}. From a

nursing management perspective, these patients have a more critical window for postoperative antithrombotic intervention²¹, requiring more refined and individualized management strategies. Continuous monitoring during this window is essential, including dynamic assessment of bleeding signs (e.g., skin and mucosal bleeding), coagulation parameters, and puncture site conditions, to ensure effective antithrombotic therapy while enabling early detection and individualized management of bleeding risks.

Coronary calcification can limit stent expansion and lead to incomplete stent apposition, resulting in disturbed local blood flow. The resulting low shear stress environment accelerates platelet aggregation and smooth muscle cell migration^{22–24}. Furthermore, the physical barrier formed by calcified plaques may hinder the transmural delivery of antiproliferative drugs from drug-eluting stents²⁵. Therefore, nursing staff should strengthen perioperative imaging surveillance (e.g., intravascular ultrasound/optical coherence tomography) in such patients to identify early signs of inadequate stent expansion and other high-risk features.

Protective Role of Rehabilitation Management Behaviors: A New Frontier for Nursing Intervention

This study moves beyond the traditional “clinically focused, nursing-neglected” paradigm of prediction models by incorporating modifiable nursing-related indicators, making the model more applicable to real-world nursing practice. The findings highlight that patient rehabilitation management behaviors play a crucial role in predicting TVR. Better PSQI score and good medication adherence were identified as independent protective factors against TVR within 1 year after PCI. Both factors fall within the domain of nursing rehabilitation management, and their significant protective effects underscore the central role of cardiac rehabilitation and secondary prevention in post-PCI care.

Notably, this study innovatively incorporated the PSQI score into the predictive model. Sleep disturbances not only activate the sympathetic nervous system—leading to fluctuations in blood pressure and heart rate and increased vascular wall tension—but they also contribute to a state of chronic systemic inflammation^{26–28}. These findings suggest that cardiovascular nursing care should extend beyond physiological monitoring to include attention to patients’ psychophysiological balance. Interventions such as cognitive behavioral therapy or sleep hygiene education may represent low-cost, high-yield strategies for reducing TVR risk.

Good medication adherence, particularly long-term, standardized use of antiplatelet agents and statins, is essential for maintaining stent endothelialization^{21,28}. Poor adherence may result in insufficient antiplatelet effects, thereby increasing the risks of thrombosis and repeat revascularization¹⁹. As primary providers of patient education, nursing staff should be vigilant regarding patients’ insufficient awareness of lifelong medication requirements. Post-PCI management should therefore emphasize structured health education and follow-up interventions, including guidance on regular sleep patterns, development of individualized rehabilitation plans, reinforcement of medication adherence, and monitoring for adverse

drug reactions. Through systematic nursing interventions, medication adherence can be significantly improved, thereby reducing TVR risk.

Stent Characteristics and Procedural Optimization

Stent diameter was identified as a protective factor (OR 0.378), which further supports the concept that a larger lumen area can tolerate a certain degree of neointimal hyperplasia, thereby improving hemodynamic conditions and reducing the risks of restenosis and TVR. Previous studies have also shown that smaller-diameter stents are more likely to cause local blood flow stagnation, increasing the risks of thrombosis and neointimal proliferation, ultimately leading to a higher incidence of TVR²⁹. In addition, adequate stent expansion is critical for long-term outcomes. Particularly in complex lesions, insufficient expansion may result in incomplete stent apposition, increasing the likelihood of complications and TVR²².

In clinical nursing practice, patients receiving small-diameter stents should be prioritized for close follow-up, with increased monitoring frequency and dynamic assessment of their condition. Nurses should also collaborate with physicians to evaluate procedural outcomes and guide patients in standardized medication use, thereby reducing TVR risk and improving long-term prognosis.

The nomogram developed in this study demonstrated good predictive performance for TVR within 1 year after PCI. LASSO regression was applied for variable selection, followed by multivariable logistic regression for model construction, effectively addressing multicollinearity among the variables. With multicenter external validation, the model showed good discriminative ability in predicting early TVR after PCI. The Hosmer–Lemeshow test indicated good model calibration. DCA further demonstrated that intervention strategies guided by this model yielded substantial clinical net benefit. The model is simple and intuitive, does not require complex calculations, and can be readily applied by nursing staff at the bedside for risk stratification. It enables prioritization of high-risk patients for intensified management in the face of limited healthcare resources.

Limitations

The main limitation of this study was the retrospective design, posing the inherent risk of selection bias. Future prospective multicenter cohort studies should be conducted in the future to further optimize the model, validate the effectiveness of nursing strategies, and establish standardized nursing pathways.

Conclusions

This study demonstrated that lesion complexity determined baseline prognosis, warranting enhanced follow-up and targeted monitoring. Rehabilitation management behaviors, particularly improvements in sleep quality and medication adherence, were identified as key modifiable factors influencing outcomes. Optimizing the allocation of nursing resources to achieve precise and individualized care is therefore essential. The visualized risk prediction model for 1-year TVR after PCI, developed by integrating clinical

baseline variables with nursing rehabilitation indicators, exhibited excellent predictive performance after external validation. The model enabled early risk stratification and guided targeted nursing interventions, offering significant clinical value in reducing TVR events and improving long-term patient prognosis.

Glossary

PCI, percutaneous coronary intervention

TVR, target vessel revascularization

OR, odds ratios

CI, 95 % confidence intervals

Δ , delta

ROC, area under the receiver operating characteristic curve

BMI, body mass index;

PLT, Platelet;

Cr, Creatinine;

HbA1c, Glycosylated Hemoglobin;

LDL-C, Low Density Lipoprotein Cholesterol;

HDL-C, High-Density Lipoprotein Cholesterol;

non-HDL-C, Non-High-Density Lipoprotein Cholesterol;

NHHR, Non-High-Density Lipoprotein Cholesterol to High-Density Lipoprotein Cholesterol Ratio

ADP Adenosine Diphosphate;

AA, Arachidonic Acid;

RA, rotational atherectomy;

LAD, left anterior descending;

LCX, left circumflex;

LM, left main;

RCA, right coronary artery;

IVUS, Intravascular Ultrasound;

OCT, Optical Coherence Tomography;

PSQI, Pittsburgh Sleep Quality Index;

IPAQ, International Physical Activity Questionnaire;

MARS-5, Medication Adherence Report Scale;

NRS-2002, Nutritional Risk Screening 2002.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest.

Data availability

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

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Authors' contributions

Juntao Duan: conceptualisation, methodology, funding acquisition, project administration, writing review.

Sai Zhang: methodology, project administration, validation, writing—review & editing.

Zhiyun Yang&Guohao He&Boyang Wei: statistical analysis.

Shu Ding&Jifang Cheng: clinical data collection.

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Tables

Table 1. Univariable analysis results in the groups with and without TVR.

Variable	TVR (n = 55)	No TVR (n = 427)	<i>P</i>
Continuous variables			
Age	69.00 (57.00–78.50)	64.00 (55.00–69.00)	0.004
Weight	70.00 (63.00–76.00)	71.00 (62.00–80.00)	0.239
Height	168.00 (162.00–170.00)	168.00 (163.00–174.50)	0.104
BMI	25.39 (22.64–27.40)	25.00 (23.03–27.66)	0.712
PLT 1	200.00 (150.00–252.50)	209.00 (174.00–249.00)	0.507
PLT 2	194.00 (162.00–247.50)	196.00 (166.00–236.00)	0.930
ΔPLT	-8.00 (-28.00–14.00)	-11.00 (-35.00–13.00)	0.516
Cr 1	75.00 (61.00–86.00)	76.00 (65.00–89.00)	0.782
Cr 2	76.00 (66.50–95.50)	74.00 (62.00–90.00)	0.139
ΔCr	4.00 (-7.00–14.00)	-1.00 (-9.50–8.50)	0.025
HbA1c 1	6.30(5.80,7.50)	6.10 (5.60–6.90)	0.081
HbA1c 2	6.30 (5.75–7.55)	6.10 (5.60–6.65)	0.019
ΔHbA1c	0.00 (-0.35–0.40)	0.00 (-0.30–0.30)	0.563
LDL-C 1	2.41 (2.06–3.18)	2.39 (1.68–3.09)	0.378
LDL-C 2	1.49 (1.21–1.83)	1.47 (1.23–1.86)	0.625
ΔLDL-C	-0.74 (-1.53--0.04)	-0.81 (-1.49--0.23)	0.831
HDL-C 1	1.00 (0.89–1.14)	0.97 (0.85–1.13)	0.415
HDL-C 2	1.02 (0.87–1.16)	1.00 (0.86–1.21)	0.966
ΔHDL-C	-0.03 (-0.10–0.11)	0.05 (-0.10–0.18)	0.121
non-HDL-C1	3.36 (2.65–3.92)	3.09 (2.22–3.91)	0.335
non-HDL-C2	2.12 (1.75–2.51)	2.01 (1.67–2.45)	0.329
Δnon-HDL-C	-0.99 (-1.72--0.13)	-0.99 (-1.79--0.23)	0.799
NHHR1	3.40 (2.54–4.15)	3.17 (2.27–4.17)	0.458
NHHR2	2.05 (1.53–2.78)	1.99 (1.58–2.51)	0.492
ΔNHHR	-1.07 (-1.67--0.25)	-1.00 (-2.21--0.19)	0.980
ADP 1	51.00 (33.00–62.00)	42.00 (27.50–58.00)	0.054
ADP2	38.00 (25.50–46.50)	35.00 (24.00–47.00)	0.596

ΔADP	-10.40 (-16.00–-2.50)	-10.00 (-18.00–6.00)	0.326
AA 1	12.00 (10.00–18.00)	11.00 (9.00–14.50)	0.120
AA 2	10.00 (9.00–13.00)	10.00 (8.00–12.00)	0.055
ΔAA	-2.00 (-5.50–2.00)	-2.00 (-5.00–2.00)	0.521
Stent diameter	2.75 (2.62–3.00)	3.00 (2.75–3.50)	0.006
Stent length	23.00 (18.00–31.50)	22.00 (18.00–30.00)	0.355
Cumulative length	30.00 (20.00–48.50)	26.00 (18.00–38.00)	0.062
Binary variables			
Gender	20 (36.4%)	108 (25.3%)	0.112
Smoking	22 (40.0%)	191 (44.7%)	0.603
Alcohol	24 (43.6%)	183 (42.9%)	0.999
Hypertension	35 (63.6%)	274 (64.2%)	0.999
Diabetes	25 (45.5%)	155 (36.3%)	0.241
Hyperlipidemia	21 (38.2%)	173 (40.5%)	0.852
RA	2 (3.6%)	8 (1.9%)	0.319
Shockwave	1 (1.8%)	12 (2.8%)	0.999
Cutting	38 (69.1%)	321 (75.2%)	0.418
Thrombus	10 (18.2%)	27 (6.3%)	0.005
LM	2 (3.6%)	6 (1.4%)	0.229
LAD	28 (50.9%)	252 (59.0%)	0.317
LCX	6 (10.9%)	55 (12.9%)	0.843
RCA	19 (34.5%)	114 (26.7%)	0.287
Non-complex lesions	23 (41.8%)	260 (60.9%)	0.011
Left main lesion	7 (12.7%)	22 (5.2%)	0.036
Ostial lesion	18 (32.7%)	71 (16.6%)	0.007
Bifurcation lesion	19 (34.5%)	120 (28.1%)	0.404
Use of imaging examination	12 (21.8%)	111 (26.0%)	0.614
IVUS	7 (12.7%)	84 (19.7%)	0.291
OCT	5 (9.1%)	29 (6.8%)	0.573

Antiplatelet strategy	19 (34.5%)	216 (50.6%)	0.036
Ordinal categorical variables			
Calcification	2.0 (1.0–2.0)	0.0 (0.0–0.0)	<0.001
PSQI	1.0 (0.0–1.0)	1.0 (1.0–2.0)	<0.001
IPAQ	2.0 (1.0–2.0)	2.0 (1.0–2.0)	0.944
MARS-5	1.0 (0.0–2.0)	1.0 (1.0–2.0)	0.007
NRS-2002	1.0 (1.0–2.0)	1.0 (1.0–2.0)	0.677

BMI, body mass index; PLT, Platelet; Cr, Creatinine; HbA1c, Glycosylated Hemoglobin; LDL-C, Low Density Lipoprotein Cholesterol; HDL-C, High-Density Lipoprotein Cholesterol; non-HDL-C, Non-High-Density Lipoprotein Cholesterol; NHHR, Non-High-Density Lipoprotein Cholesterol to High-Density Lipoprotein Cholesterol Ratio; ADP, Adenosine Diphosphate; AA, Arachidonic Acid; RA, rotational atherectomy; LAD, left anterior descending; LCX, left circumflex; LM, left main; RCA, right coronary artery; IVUS, Intravascular Ultrasound; OCT, Optical Coherence Tomography; PSQI, Pittsburgh Sleep Quality Index; IPAQ, International Physical Activity Questionnaire; MARS-5, Medication Adherence Report Scale; NRS-2002, Nutritional Risk Screening 2002.

Table 2. Logistic regression analysis of risk factors associated with TVR at 1 year after PCI.

Variable	β	SE	OR	95%CI	P
Age	0.003	0.018	1.003	0.968 – 1.038	0.887
Δ Cr	0.016	0.010	1.016	0.996 – 1.036	0.116
HbA1c 2	0.201	0.139	1.222	0.930 – 1.607	0.150
Stent diameter	-0.974	0.466	0.378	0.152 – 0.942	0.037
Thrombus	1.358	0.588	3.888	1.228 – 12.313	0.021
Non-complex lesions	-0.584	0.375	0.557	0.267 – 1.163	0.119
Left main lesion	0.435	0.634	1.545	0.446 – 5.356	0.493
Antiplatelet strategy	-0.339	0.413	0.712	0.317 – 1.600	0.411
Calcification	1.185	0.205	3.272	2.187 – 4.894	0.000
PSQI	-1.218	0.312	0.296	0.161 – 0.545	0.000
MARS-5	-0.769	0.267	0.463	0.275 – 0.782	0.004

PCI, percutaneous coronary intervention; TVR, target vessel revascularization.

Cr,Creatinine; HbA1c,Glycosylated Hemoglobin; PSQI,Pittsburgh Sleep Quality Index; MARS-5,Medication Adherence Report Scale.

OR, odds ratios; CI, 95 % confidence intervals.

Figures

Figure 1a. LASSO regression coefficient path plot.

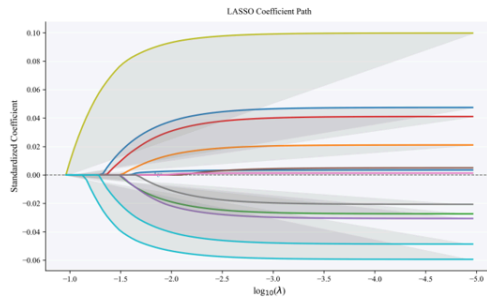


Figure 1b. Optimal lambda value determined by 10-fold cross-validation.

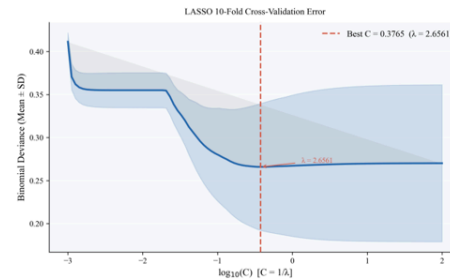


Figure 1

Variable screening via LASSO regression.

(a)Coefficient path plot of the LASSO regression model. With increasing penalty parameter λ , regression coefficients of candidate variables were shrunk toward zero.

(b)Identification of the optimal λ value via 10 fold cross validation, corresponding to the minimum binomial deviance.

Abbreviation: LASSO, Least Absolute Shrinkage and Selection Operator; PCI, percutaneous coronary intervention; TVR,targetvessel revascularization.

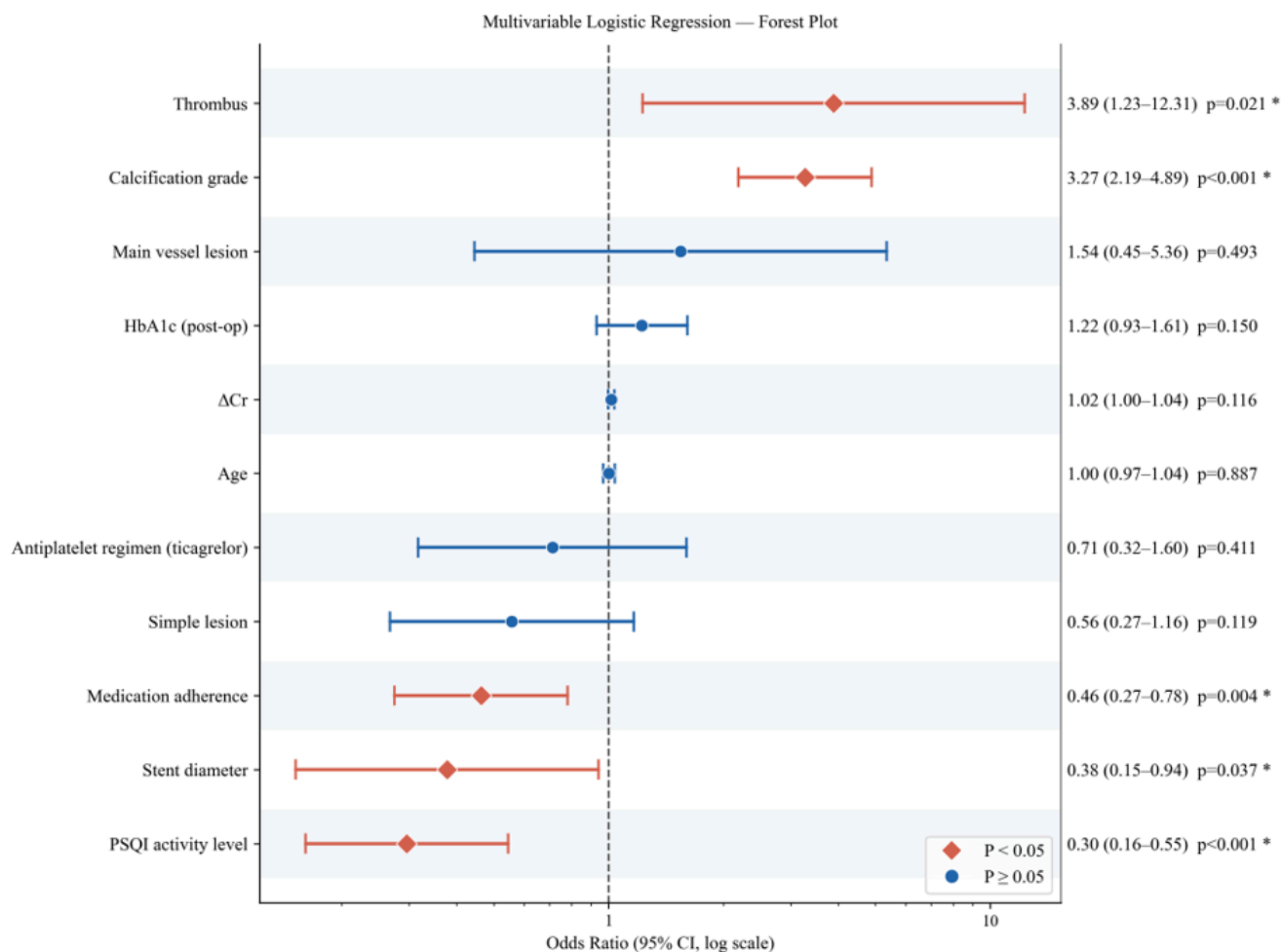


Figure 2

Forest plot of the multivariate logistic regression analysis.

The forest plot shows the ORs and 95% CIs of candidate variables. Thrombus, calcification grade, stent diameter, PSQI score, and MMARS-5 score were identified as independent predictors (all P < 0.05).

Abbreviations: HbA1c, glycated hemoglobin; Cr, creatinine; OR, odds ratio; CI, confidence interval

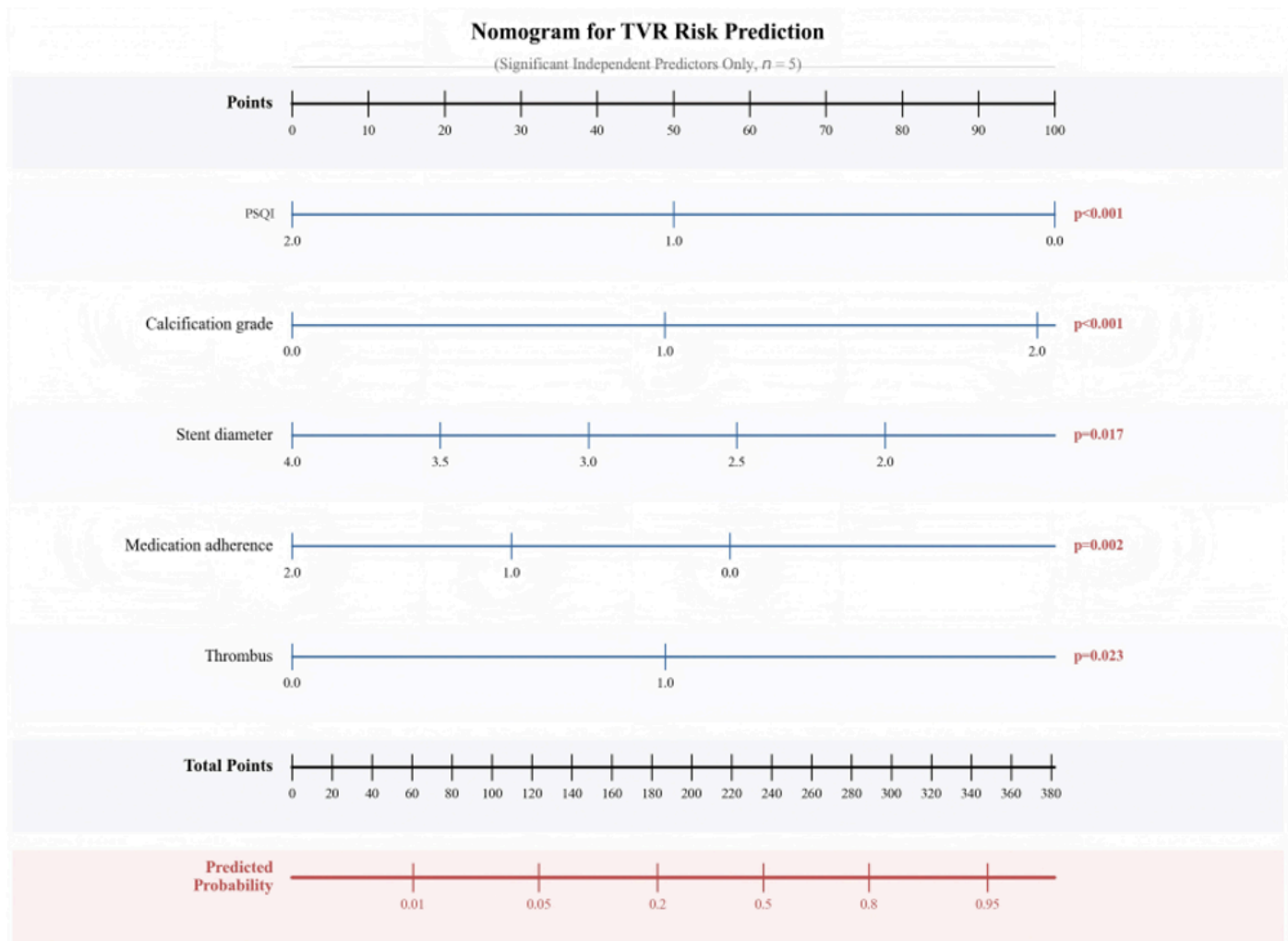


Figure 3

Nomogram of the TVR risk prediction model.

The nomogram was constructed based on five independent predictors, including thrombus, calcification grade, stent diameter, PSQI score, and MARS-5 score. Each variable was assigned a corresponding point score, and the total points were used to calculate the individual probability of 1 year TVR after PCI.

Abbreviations: TVR, target vessel revascularization; PCI, percutaneous coronary intervention; PSQI, Pittsburgh Sleep Quality Index; MARS-5, Medication Adherence Rating Scale.

Figure 4a. ROC curve of the prediction model (training cohort).

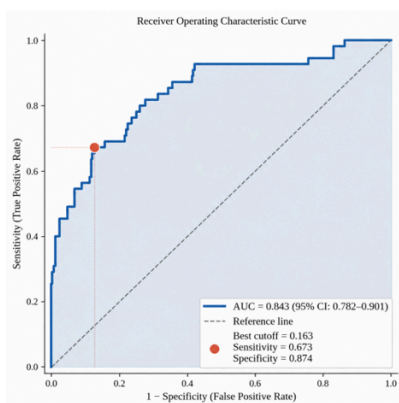


Figure 4b. ROC curve of the prediction model (validation cohort).

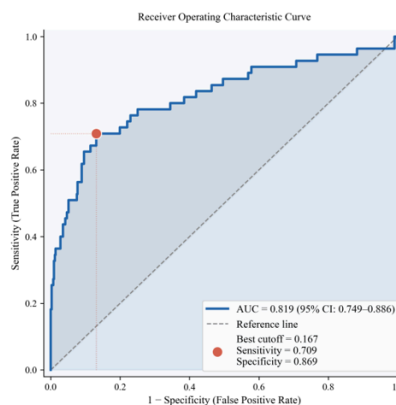


Figure 4

ROC curves of the prediction model.

(a) ROC curve in the derivation cohort, showing an area under AUC of 0.843 (95% CI 0.782-0.901).

(b) ROC curve in the external multicenter validation cohort, showing an AUC of 0.819 (95% CI 0.749-0.886).

Abbreviations: TVR, target vessel revascularization; PCI, percutaneous coronary intervention; ROC, receiver operating characteristic; AUC, area under the curve; CI, confidence interval.

Figure 5a. Calibration plot of the prediction model.

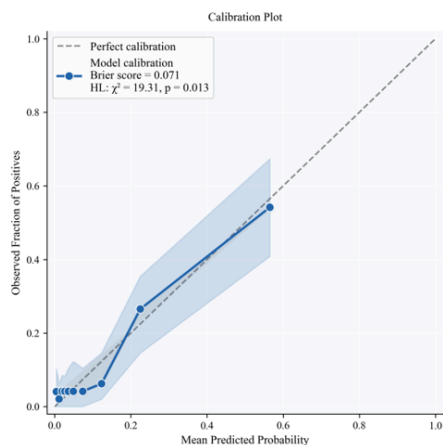


Figure 5b. DCA of the prediction model. DCA, decision curve analysis.

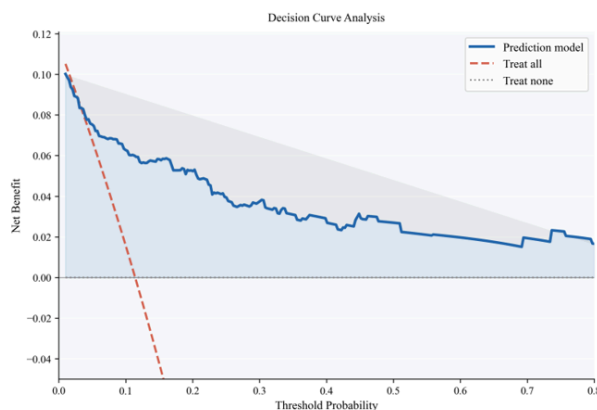


Figure 5

Calibration and clinical benefit of the prediction model.

(a) Calibration plot showing excellent agreement between predicted and observed probabilities of 1 year TVR.

(b) DCA demonstrating favorable clinical net benefit across a wide range of threshold probabilities.

Abbreviations: TVR, target vessel revascularization; PCI, percutaneous coronary intervention; DCA, decision curve analysis.