Patient Preference and Adherence

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ORIGINAL RESEARCH

Factors Influencing Cardiac Rehabilitation Compliance in Elderly Myocardial Infarction Patients and the Development of a Nomogram Prediction Model

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Objective: To explore the influencing factors of cardiac rehabilitation compliance in elderly patients with acute myocardial infarction (AMI) and to construct a nomogram prediction model.

Methods: A retrospective study was conducted on 239 elderly AMI patients admitted to our hospital from April 2022 to April 2024. The patients were randomly assigned into a modeling group (167 cases) and a validation group (72 cases) in a 7:3 ratio. The modeling group was separated into a good compliance group and a poor compliance group based on their compliance with cardiac rehabilitation.

Results: Among the 167 patients in the modeling group, 67 had poor compliance, with an incidence rate of 40.12%. Multivariate logistic regression revealed that age, educational level, perception of disease, anxiety and depression, social support, and medical staff supervision were risk factors for cardiac rehabilitation compliance in elderly AMI patients ($P<0.05$). The AUC values of the modeling and validation groups were 0.955 and 0.937, respectively. The slope of the calibration curve was close to 1, and the H-L test showed $\chi^2=7.863$ and 7.453, with $P=0.789$ and 0.775, indicating good consistency. DCA curve showed that when the high-risk threshold probability was between 0.08 and 0.93, the nomogram model had a high clinical value.

Conclusion: Age, educational level, perception of the disease, anxiety and depression, social support, and medical staff supervision are the influencing factors of cardiac rehabilitation compliance in elderly AMI patients. The nomogram model constructed based on this has good discrimination and consistency, and can predict cardiac rehabilitation compliance.

Keywords: myocardial infarction, cardiac rehabilitation, compliance, influencing factors, nomogram

Introduction

Acute myocardial infarction (AMI) occurs when a thrombus forms in the coronary artery, blocking the vessel on the basis of coronary atherosclerosis, leading to a decrease in the blood supply to myocardial cells. Myocardial hypoxia and coronary artery spasms can also cause myocardial ischemia and necrosis in the cells.[1] AMI may result in persistent arrhythmias, heart failure, and other complications in patients, with a high mortality rate, posing a serious threat to life and health.[2] Cardiac rehabilitation can effectively alleviate the symptoms of AMI patients and control the progression of the disease. Early comprehensive rehabilitation activities are an important method of cardiac rehabilitation for AMI,[3,4] mainly including educational counseling, exercise therapy, and other interventions. Through active cooperation from the patients, cardiovascular function recovery is promoted, ensuring that the patient's physiological and psychological state remains in good condition. Moreover, compliance with cardiac rehabilitation directly impacts the rehabilitation outcome.[5] Therefore, identifying the factors affecting compliance with cardiac rehabilitation in AMI patients is crucial for improving patient prognosis. Nomograms are simple to operate and highly readable, allowing the individualized prediction of the risk of an event by integrating the risk factors screened from regression analysis.[6,7] Based on this,

Received: 21 March 2025
Accepted: 7 July 2025
Published: 11 July 2025

research on the compliance of elderly AMI patients with cardiac rehabilitation in nomograms is rarely reported. Therefore, this study aims to explore the factors affecting the compliance of elderly AMI patients with cardiac rehabilitation and to construct a predictive model using nomograms.

Materials and Methods

General Data

A retrospective selection of 239 elderly AMI patients admitted to our hospital from April 2022 to April 2024 was made. The patients were randomly divided into the modeling group (167 cases) and the validation group (72 cases) according to a 7:3 ratio (random number table method). The patients in the modeling group were divided into good compliance and poor compliance groups according to their cardiac rehabilitation compliance. The case collection process is shown in Figure 1. Inclusion criteria: (1) Meeting the diagnostic criteria for AMI;[8] (2) Age ≥ 60 years; (3) Complete data. Exclusion criteria: (1) Liver and kidney dysfunction; (2) Systemic infectious diseases; (3) Unstable vital signs; (4) Malignant tumors; (5) Blood system diseases; (6) Hearing and visual impairment. This study was approved by the hospital ethics committee. See Figure 1.

Cardiac Rehabilitation Compliance Assessment

The cardiac rehabilitation compliance of the patients was evaluated using the Cardiac Rehabilitation Scale.[9] This scale includes 3 dimensions (autonomy, process anxiety, and outcome anxiety) and 18 items. Each item is rated on a 5-point Likert scale. Autonomy scores ≤ 15 indicate poor autonomy, process anxiety ≥ 19 indicates high process anxiety, and outcome anxiety ≥ 10 indicates high outcome anxiety. The scale has good reliability and validity, with a coefficient of 0.825.

Clinical Data

Clinical routine examination and electronic medical record data were collected, including age, gender, body mass index (BMI), first-time diagnosis, marital status, education level, place of residence, history of hypertension, history of diabetes, history of kidney disease, anxiety and depression, smoking history, alcohol abuse, disease perception, social support, healthcare supervision, method of medical expense payment, rehabilitation location, total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), glycosylated hemoglobin (HbA1c), fasting blood glucose (FBG), albumin, and uric acid levels.

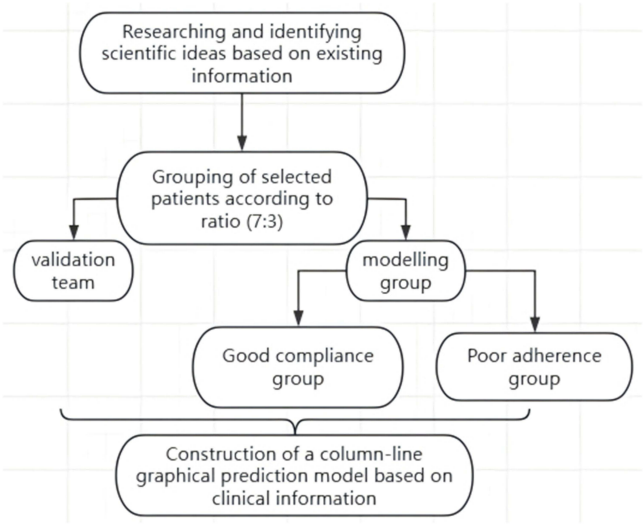

Figure 1 Flow chart of case collection.

Statistical Analysis

Data were analyzed using SPSS 25.0. Categorical data were tested using the χ^2-test and expressed as cases (%). Continuous data that followed a normal distribution were tested using the *t*-test and expressed as $\bar{x} \pm s$. Multivariate logistic regression analysis was used to identify factors influencing cardiac rehabilitation compliance in elderly AMI patients. The nomogram model for cardiac rehabilitation compliance in elderly AMI patients was constructed using R software. The ROC curve was drawn to evaluate the discrimination of the nomogram model for cardiac rehabilitation compliance in elderly AMI patients. The calibration curve was drawn to evaluate model consistency. The clinical decision curve (DCA) was used to assess the clinical application value of the model. $P < 0.05$ was considered statistically significant.

Results

Comparison of Clinical Data Between the Modeling Group and Validation Group

There were no differences in the clinical data between the modeling group and the validation group ($P > 0.05$). See Table 1.

Table 1 Comparison of Clinical Data Between Modelling and Validation Group

Considerations	Modelling Group (n=167)	Validation Group(n=72)	t/χ^2	*P*
Age (years)			0.366	0.545
≥60	79 (47.31)	31 (43.06)		
<60	88 (52.69)	41 (56.94)		
Genders			0.012	0.913
Man	101 (60.48)	43 (59.72)		
Woman	66 (39.52)	29 (40.28)		
BMI (kg/m^2)			0.076	0.782
<24	96 (57.49)	40 (55.56)		
≥24	71 (42.51)	32 (44.44)		
Primary patients			0.615	0.433
Yes	72 (43.11)	35 (48.61)		
No	95 (56.89)	37 (51.39)		
Marital status			0.059	0.808
Married	114 (68.26)	48 (66.67)		
Unmarried, divorced or widowed	53 (31.74)	24 (33.33)		
Educational attainment			0.009	0.925
Junior high school and below	73 (43.71)	31 (43.06)		
High school and above	94 (56.29)	41 (56.94)		
Current address			0.322	0.570
Municipalities	113 (67.66)	46 (63.89)		
Countryside	54 (32.34)	26 (36.11)		
History of hypertension			0.208	0.648
Yes	35 (20.96)	17 (23.61)		
No	132 (79.04)	55 (76.39)		
History of diabetes			0.045	0.831
Yes	26 (15.57)	12 (16.68)		
No	141 (84.43)	60 (83.33)		
History of kidney disease			0.522	0.470
Yes	24 (14.37)	13 (18.06)		
No	143 (85.63)	59 (81.94)		
Anxiety and depression			0.243	0.622
Yes	73 (43.71)	29 (40.28)		
No	94 (56.29)	43 (59.72)		

(*Continued*)

https://doi.org/10.2147/PPA.S529753

Table 1 (Continued).

Considerations	Modelling Group (n=167)	Validation Group(n=72)	t/χ^2	*P*
Smoking history			0.090	0.764
Yes	41 (24.55)	19 (26.39)		
No	126 (75.45)	53 (73.61)		
History of alcohol abuse			0.059	0.808
Yes	53 (31.74)	24 (33.33)		
No	114 (68.26)	48 (66.67)		
Perception of disease			0.168	0.682
Good	86 (51.50)	35 (48.61)		
Poor	81 (48.50)	37 (51.39)		
Level of family support			0.172	0.678
Good	93 (55.69)	38 (52.78)		
Poor	74 (44.31)	34 (47.22)		
Social support			0.034	0.853
Good	79 (47.31)	35 (48.61)		
Poor	88 (52.69)	37 (51.39)		
Supervision by medical staff			0.033	0.856
Good	81 (48.50)	34 (47.22)		
Poor	86 (51.50)	38 (52.78)		
Methods of payment of medical expenses			0.826	0.363
Medical insurance	101 (60.48)	39 (54.17)		
Self-financed	66 (39.52)	33 (45.83)		
Rehabilitation facility			0.236	0.627
Good	103 (61.68)	42 (58.33)		
Poor	64 (38.32)	30 (41.67)		
TC (mmol/L)	4.20±0.32	4.22±0.33	0.439	0.661
TG (mmol/L)	1.90±0.25	1.88±0.23	0.581	0.562
LDL-C (mmol/L)	2.34±0.34	2.32±0.32	0.425	0.672
HDL-C (mmol/L)	1.03±0.22	1.02±0.23	0.318	0.751
HbA1c (%)	6.47±1.22	6.44±1.20	0.175	0.861
FBG (mmol/L)	5.90±1.02	5.91±1.04	0.069	0.945
Albumin (g/L)	40.32±5.23	40.28±5.26	0.054	0.957
Uric acid (μmol/L)	356.06±55.73	355.24±54.96	0.105	0.917

Status of Cardiac Rehabilitation Compliance in Elderly AMI Patients

In the modeling group of 167 patients, 67 patients had poor compliance, with an incidence rate of 40.12%. The scores for process anxiety, outcome anxiety, poor autonomy, high process anxiety, and high outcome anxiety in the poor compliance group were higher than those in the good compliance group ($P < 0.05$), and the autonomy score was also higher in the poor compliance group than in the good compliance group ($P < 0.05$). See Table 2.

Comparison of Clinical Data Between Poor Compliance and Good Compliance Groups

There were differences in age, education level, disease perception, anxiety and depression, social support, and healthcare supervision between the two groups ($P < 0.05$). No differences were found in other clinical data between the two groups ($P > 0.05$). See Table 3.

Table 2 Current Status of Adherence to Cardiac Rehabilitation Compliance in Elderly AMI Patients

Items	Poor Adherence Group (n=67)	Good Compliance Group (n=100)	t/χ^2	*P*
Cardiac Rehabilitation Scale score			0.366	0.545
Autonomy	14.80±1.37	20.57±1.62	23.967	
Process anxiety	14.89±3.42	12.53±2.46	5.186	
Anxiety about results	11.48±2.71	9.17±2.67	5.447	
Less autonomy	35 (52.24)	3 (3.00)	55.339	<0.001
High process anxiety	10 (14.93)	4 (4.00)	6.235	0.013
High outcome anxiety	38 (56.72)	12 (12.00)	38.245	

Table 3 Comparison of Clinical Data Between the Poor Adherence Group and the Good Adherence Group

Considerations	Poor Adherence Group (n=67)	Good Compliance Group (n=100)	t/χ^2	*P*
Age (years)			17.702	<0.001
≥60	45 (67.16)	34 (34.00)		
<60	22 (32.84)	66 (66.00)		
Genders			0.028	0.866
Man	40 (59.70)	61 (61.00)		
Woman	27 (40.30)	39 (39.00)		
BMI (kg/m^2)			0.027	0.869
<24	38 (56.72)	58 (58.00)		
≥24	29 (43.28)	42 (42.00)		
Primary patients			0.126	0.723
Yes	30 (44.78)	42 (42.00)		
No	37 (55.22)	58 (58.00)		
Marital status			0.050	0.822
Married	46 (68.66)	68 (67.00)		
Unmarried, divorced or widowed	21 (31.34)	32 (32.00)		
Educational attainment			16.372	<0.001
Junior high school and below	42 (62.69)	31 (31.00)		
High school and above	25 (37.31)	69 (69.00)		
Current address			0.316	0.574
Municipalities	47 (70.15)	66 (66.00)		
Countryside	20 (29.85)	34 (34.00)		
History of hypertension			0.138	0.710
Yes	15 (22.39)	20 (20.00)		
No	52 (77.61)	80 (80.00)		
History of diabetes			0.035	0.851
Yes	10 (14.93)	16 (16.00)		
No	57 (85.07)	84 (84.00)		
History of kidney disease			0.080	0.777
Yes	9 (13.43)	15 (15.00)		
No	58 (86.57)	85 (85.00)		
Anxiety and depression			19.049	<0.001
Yes	43 (64.18)	30 (30.00)		
No	24 (35.82)	70 (70.00)		

(*Continued*)

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Table 3 (Continued).

Considerations	Poor Adherence Group (n=67)	Good Compliance Group (n=100)	t/χ^2	*P*
Smoking history			0.027	0.869
Yes	16 (23.88)	25 (25.00)		
No	51 (76.12)	75 (75.00)		
History of alcohol abuse			0.008	0.929
Yes	21 (31.34)	32 (32.00)		
No	46 (68.66)	68 (68.00)		
Perception of disease			18.195	<0.001
Good	21 (31.34)	65 (65.00)		
Poor	46 (68.66)	35 (35.00)		
Level of family support			0.010	0.921
Good	37 (55.22)	56 (56.00)		
Poor	30 (44.78)	44 (44.00)		
Social support			13.675	<0.001
Good	20 (29.85)	59 (59.00)		
Poor	47 (70.15)	41 (41.00)		
Supervision by medical staff			13.190	<0.001
Good	21 (31.34)	60 (60.00)		
Poor	46 (68.66)	40 (40.00)		
Methods of payment of medical expenses			0.228	0.633
Medical insurance	42 (62.69)	59 (59.00)		
Self-financed	25 (37.31)	41 (41.00)		
Rehabilitation facility			0.185	0.667
Good	40 (59.70)	63 (63.00)		
Poor	27 (40.30)	37 (37.00)		
TC (mmol/L)	4.22±0.34	4.18±0.31	0.786	0.433
TG (mmol/L)	1.89±0.24	1.90±0.25	0.257	0.797
LDL-C (mmol/L)	2.32±0.32	2.35±0.35	0.562	0.575
HDL-C (mmol/L)	1.05±0.24	1.01±0.20	1.168	0.244
HbA1c (%)	6.42±1.20	6.50±1.24	0.414	0.679
FBG (mmol/L)	5.92±1.01	5.89±1.03	0.186	0.853
Albumin (g/L)	40.34±5.12	40.31±5.31	0.036	0.971
Uric acid (μmol/L)	354.29±56.27	357.24±55.37	0.335	0.738

Analysis of Factors Affecting Cardiac Rehabilitation Compliance in Elderly AMI Patients

With poor cardiac rehabilitation compliance in elderly AMI patients as the dependent variable (yes = 1, no = 0), the factors with significant differences mentioned above were taken as independent variables. The variable assignment method is shown in Table 4. Multivariate logistic regression analysis results showed that age, education level, disease perception, anxiety and depression, social support, and healthcare supervision were risk factors for poor cardiac rehabilitation compliance in elderly AMI patients ($P < 0.05$). See Table 5.

Establishment of the Nomogram Model for Cardiac Rehabilitation Compliance in Elderly AMI Patients

In this model, the factors affecting the scores were, in order: social support, age, disease perception, healthcare supervision, anxiety and depression, and education level. See Figure 2.

Table 4 Independent Variable Assignment Methods

Variable	Assignment Method
Age	<60 years=0, ≥60 years=1
Educational attainment	High school and above=0, Junior high school and below=1
Perception of disease	Good=0, Poor=1
Anxiety and depression	Yes=0, no=1
Social support	Good=0, Poor=1
Supervision by medical staff	Good=0, Poor=1

Table 5 Analysis of Factors Influencing Adherence to Cardiac Rehabilitation in Elderly Patients with AMI

Variable	β value	SE value	Wald χ^2 value	*P* value	OR value	95% CI
Age	2.171	0.603	12.967	<0.001	8.765	2.689~28.568
Educational attainment	1.612	0.598	7.298	0.007	5.012	1.552~16.192
Perception of disease	1.864	0.610	9.338	0.002	6.449	1.951~21.313
Anxiety and depression	1.770	0.599	8.736	0.0031	5.869	1.815~18.973
Social support	2.196	0.610	12.968	<0.001	8.987	2.720~29.690
Supervision by medical staff	1.844	0.628	8.608	0.003	6.320	1.844~21.656
Constant	−5.303	0.817	42.105	<0.001	0.005	–

Nomogram Model of the Modeling Group

The AUC of the modeling group was 0.955 (95% CI: 0.927~0.984), and the slope of the calibration curve was close to 1. The H-L test yielded $\chi^2 = 7.863$, P = 0.789, indicating good consistency. See Figure 3.

Nomogram Model of the Validation Group

The AUC of the validation group was 0.937 (95% CI: 0.884~0.991), and the slope of the calibration curve was close to 1. The H-L test yielded $\chi^2 = 7.453$, P = 0.775, indicating good consistency. See Figure 4.

DCA Curve of the Nomogram Model

The DCA curve shows that the clinical utility of using this nomogram model to evaluate the cardiac rehabilitation compliance of elderly AMI patients was high when the high-risk threshold probability was between 0.08 and 0.93. See Figure 5.

Discussion

AMI can cause the rupture of atherosclerotic plaques, thereby damaging the vascular endothelium. Moreover, thrombosis in multiple coronary arteries can lead to vascular occlusion, reducing coronary blood flow and resulting in persistent ischemia and hypoxia, eventually causing myocardial necrosis.[10] The clinical symptoms manifest as chest pain and chest tightness, and in severe cases, they can lead to arrhythmias and heart failure in patients.[11] Cardiac rehabilitation is a major clinical intervention for treating AMI. It mainly reduces the psychological and physiological effects of the disease on patients through correcting cardiac risk factors and behavioral interventions, thus improving patients' quality of life. Its effectiveness is related to the patients' compliance.[12] The results of this study found that in the modeling group of 167 patients, 67 patients had poor compliance, with an incidence rate of 40.12%. There were differences in autonomy scores, process anxiety, and outcome anxiety between the two groups. Therefore, identifying factors affecting cardiac rehabilitation compliance in AMI patients and timely prevention can effectively improve patient prognosis.

This study screened out six factors (age, education level, disease perception, anxiety and depression, social support, and healthcare supervision) through multivariate analysis and analyzed the reasons: (1) Elderly AMI patients often experience a decline in physical function and poor health, often accompanied by chronic metabolic complications and

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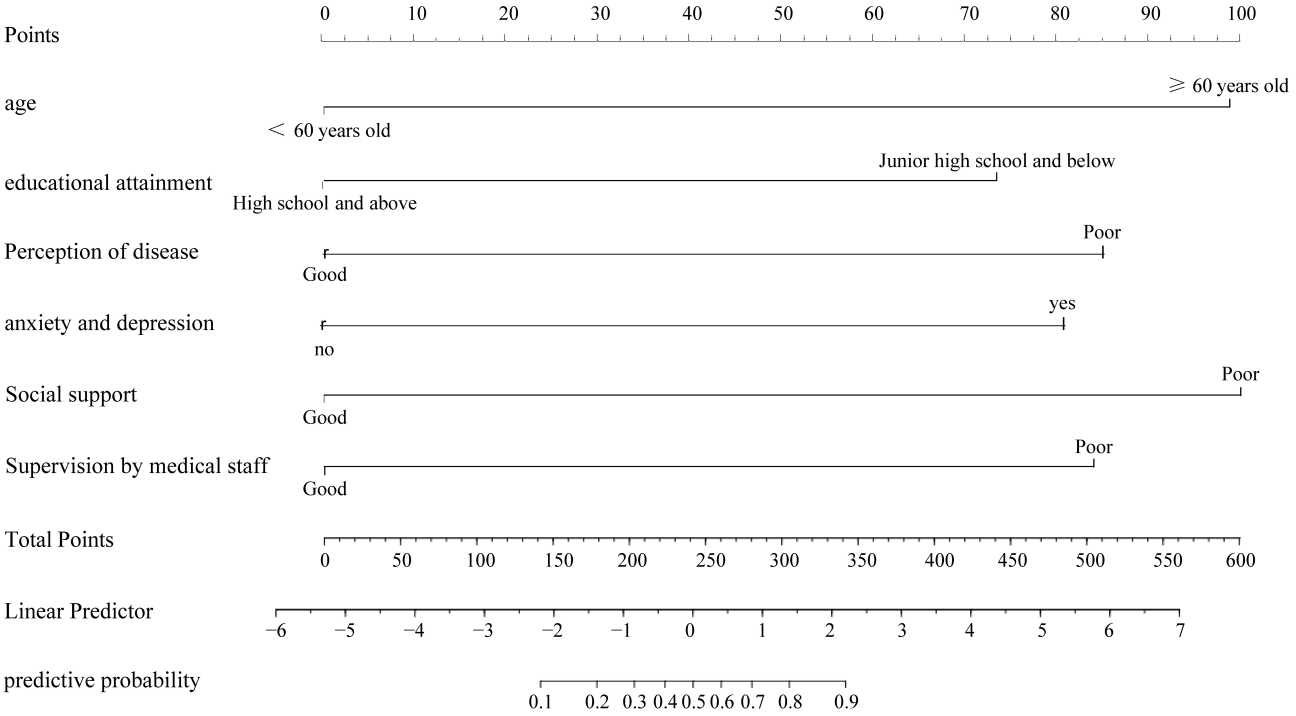

Figure 2 Development of a nomogram modelling of adherence to cardiac rehabilitation in elderly patients with AMI.

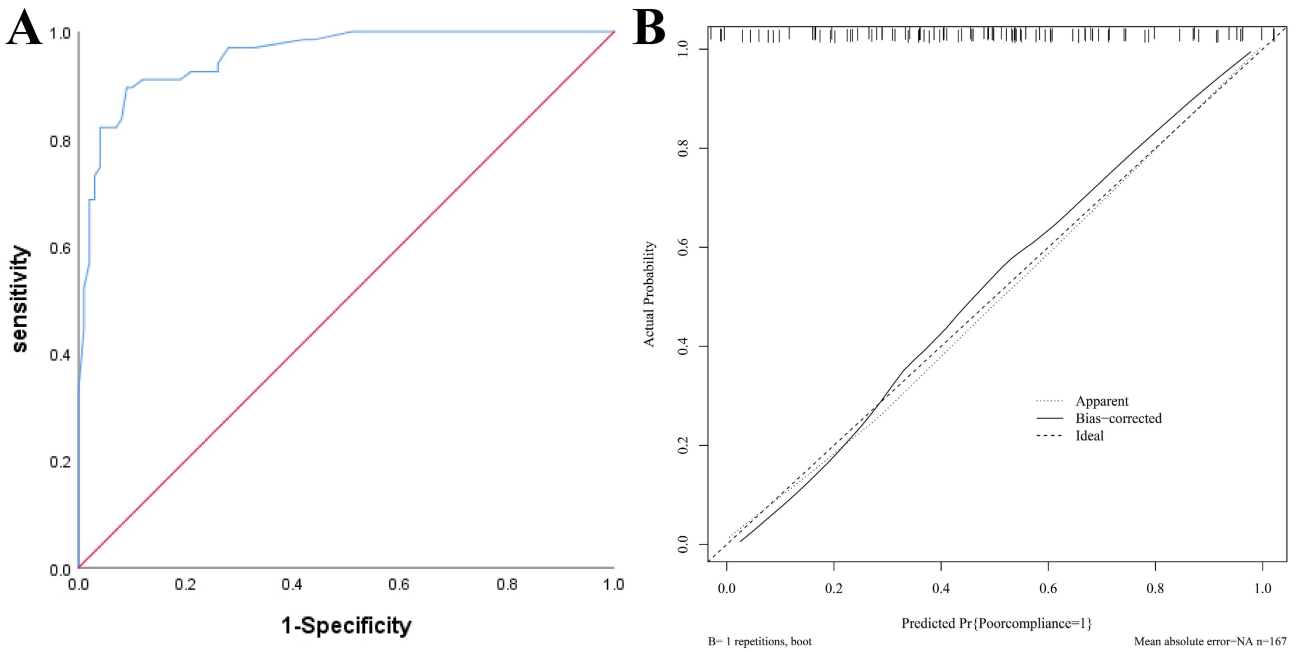

Figure 3 Nomogram Model of the Modeling Group, (**A**) ROC curve for modelling group; (**B**) Modelling group calibration curves.

limited mobility. On the one hand, cardiac rehabilitation may not be pursued due to rehabilitation contraindications. On the other hand, the physical changes brought about by cardiac rehabilitation in elderly patients may not be apparent, leading to lower compliance.[13,14] (2) Studies have shown that education level is related to treatment compliance in AMI patients. Patients with higher education levels can communicate more effectively,[4] while those with lower education levels often lack sufficient awareness of cardiac rehabilitation. Some patients with lower economic levels also do not

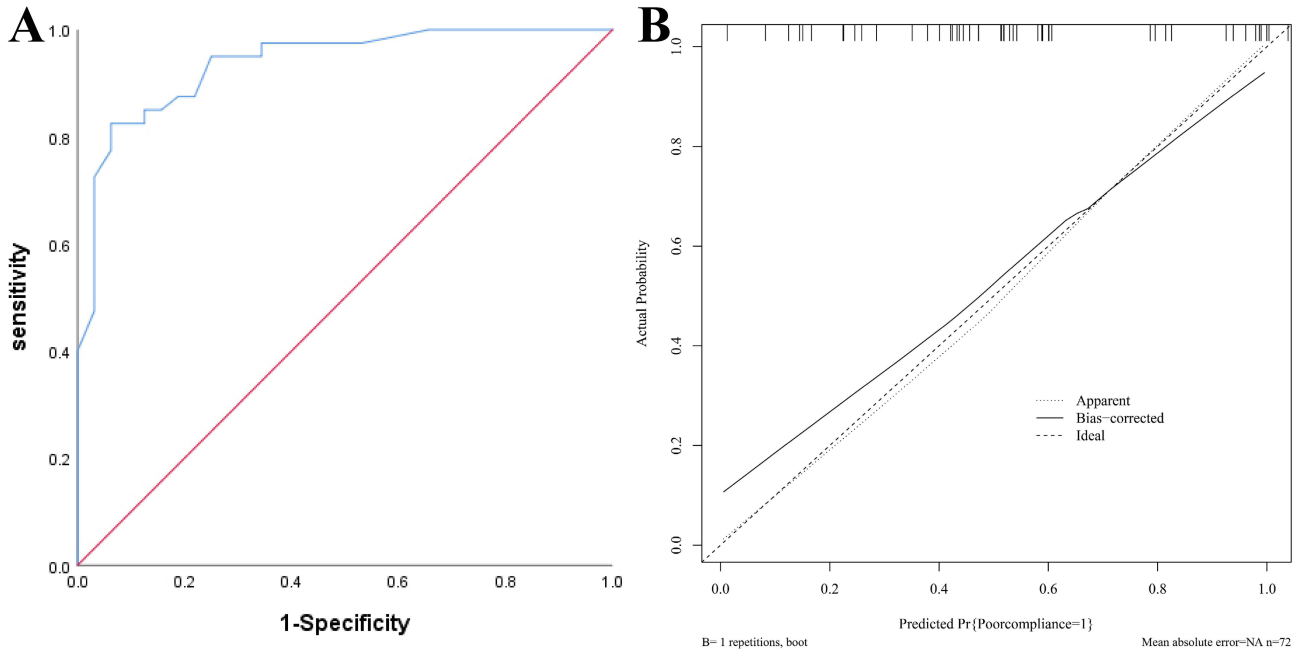

Figure 4 Nomogram Model of the Validation Group, (**A**) ROC curve for the validation group; (**B**) Calibration curve for the validation group.

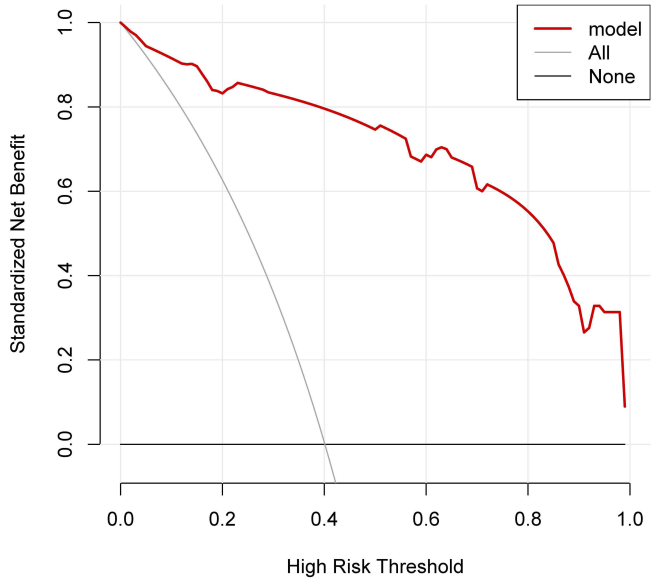

Figure 5 DCA curve for the nomogram.

prioritize their health, all of which affect compliance,[15] which is similar to the results of this study. For patients with lower education levels, healthcare professionals need to repeatedly emphasize its importance and guide family members to supervise cardiac rehabilitation training.(3) Disease perception is also a risk factor affecting cardiac rehabilitation compliance. Patients with poor perception are less aware of the importance of cardiac rehabilitation, more likely to fear the disease, and have low expectations for treatment, resulting in the misconception that rehabilitation therapy has little significance, which reduces compliance.[16] (4) Anxiety and depression are also reasons for poor compliance with cardiac rehabilitation treatment. Patients who are long-term in a negative emotional state of anxiety and depression tend to neglect cardiac rehabilitation training. Furthermore, AMI is prone to complications, and patients worry about the occurrence of complications, which leads to emotional lows and reduced compliance.[17,18] (5) Social support is also

https://doi.org/10.2147/PPA.S529753

a risk factor affecting cardiac rehabilitation. Most patients acquire relevant knowledge about the disease through family and friends. Their support and encouragement help patients build confidence in overcoming the disease and improve their participation in cardiac rehabilitation.[19] (6) Healthcare providers must select appropriate cardiac rehabilitation training based on the patient's actual situation, ensuring the effectiveness of the training while avoiding exacerbating the patient's financial burden. Professional support should be provided to supervise the patient's training, encourage emotional support from family and friends, and actively guide patients to participate in cardiac rehabilitation training to improve compliance.[20] Some studies have found that anthropometric indicators (such as thoracic morphology) can influence adherence to cardiac rehabilitation.[21] However, this study mainly focused on patients' general information and social factors, which is a limitation. Further research will be conducted to explore this aspect in the future.

Through the construction of a nomogram model, this study found that the AUC of the modeling group and validation group was 0.955 and 0.937, respectively, indicating high discrimination. The slope of the calibration curve was close to 1, showing good consistency between the model's risk assessment and actual risk. Additionally, the DCA curve showed that when the high-risk threshold probability was between 0.08 and 0.93, the clinical application value of this nomogram model was high. It can help clinicians assess the risk of cardiac rehabilitation compliance in patients based on influencing factors and prevent non-compliance early to improve patient outcomes.

In conclusion, age, education level, disease perception, anxiety and depression, social support, and healthcare supervision are factors affecting cardiac rehabilitation compliance in elderly AMI patients. The nomogram model built on these factors showed good discrimination and consistency and can predict patients' cardiac rehabilitation compliance. Further validation with larger sample sizes is needed in future studies. This study has several limitations. As a retrospective study, there may be selection bias in the sample size. Additionally, it is a single-center study with a relatively small sample size. Future research will involve prospective, multicenter studies with a larger sample size for further validation.

Data Sharing Statement

The original contributions presented in the study are included in the article.

Ethics Statement

The study was in accordance with Yueyang People's Hospital ethics review board (2022-04-047) and with the 1964 Helsinki Declaration. Written informed consent to participate in this study was provided by the participants.

Disclosure

All authors declare no conflicts of interest.

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