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Article

Analysis of the Reliability and Validity of the Johns Hopkins Fall Risk Assessment Scale in Patients with Acute Myocardial Infarction after Percutaneous Coronary Intervention

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Abstract

Objective: To analyze the reliability and validity of the Johns Hopkins Fall Risk Assessment Scale (JHFRAS) for out-of-bed fall risk in patients with acute myocardial infarction (AMI) after percutaneous coronary intervention (PCI). **Methods**: This study adopted continuity inclusion with the Chinese version of JHFRAS to test patients with AMI after PCI who were admitted to our hospital from January 2021 to December 2022. The occurrence of falls during out-of-bed activities was counted through follow-up, and the predictive value of the scale was assessed by using the area under the curve (AUC) of the receiver operator characteristic curve and determining sensitivity, specificity, Jordon's index, and critical value. The internal consistency reliability (Cronbach's α coefficient), interrater reliability (Spearman correlation analysis was conducted to analyze the scores obtained through the independent and simultaneous assessment of two reviewers who were unaware of the content and results of the scale), content validity (expert evaluation involving four experts), and criterion-related validity (the score of the Morse fall assessment scale [rMFS] was used as an indicator of criterion-related validity) were determined. **Results**: Through follow-up, this study found that 11 cases experienced falls during out-of-bed activities and 69 cases did not experience falls. The JHFRAS scores of the nonfall and fall groups were significantly different ($p < 0.05$). JHFRAS, which was designed to predict the risk of falls during out-of-bed activities in post-PCI patients with AMI, had an AUC of 0.880, a sensitivity of 0.937, a specificity of 0.824, a Jordon's index of 0.760, and a critical value of 9 points. Its Cronbach's α coefficient was 0.803. The assessment data from two reviewers were analyzed via intragroup coefficient analysis and yielded a Spearman's rank correlation coefficient of 0.948. The overall content validity of the scale was 0.968. The content validity indices of age, fall history, urine and defecation excretion amount, high-risk drug use, stent number, action capability, and cognitive ability were 0.915, 0.924, 0.938, 0.920, 0.954, 0.960 and 0.972, respectively. All correlation coefficients were significant at the 0.01 level. The scores of each dimension of rMFS and JHFRAS showed positive correlations. **Conclusions**: JHFRAS has good reliability and validity and can be used to assess the fall risk of out-of-bed activities in patients with AMI after PCI.

Keywords

Johns Hopkins Fall Risk Assessment Scale; acute myocardial infarction; percutaneous coronary intervention; reliability and validity

Introduction

According to a relevant survey [1], patients with myocardial infarction are prone to falling after percutaneous coronary intervention (PCI). The incidence of falls in such patients is approximately 13.48%. Falls increase patients' physical and mental burden; affect postoperative recovery; and even cause serious consequences, such as disability, disability and death, exerting a negative effect on hospitals and even resulting in medical disputes [2,3]. Therefore, evaluating the fall risk of patients after PCI in advance is necessary. The control of out-of-bed activities in patients with acute myocardial infarction (AMI) after PCI mainly lies in prediction and prevention. Numerous domestic and international assessment scales for predicting fall risk exist [4–6]. The Johns Hopkins Fall Risk Assessment Scale (JHFRAS) was evaluated and revised after 2 years of application in adult inpatients at Johns Hopkins Hospital. This scale has strong operability and high practicability in all adult patients in the clinic. Studies have shown that its sensitivity and specificity for predicting fall-induced injuries are 100% and 65.9%, respectively [7–10]. However, this scale has not been validated in patients with AMI after PCI. Therefore, this study analyzed the reliability and validity of JHFRAS in assessing the fall risk of patients with AMI after PCI. Specifically, the reliability and validity of JHFRAS in assessing fall risk in patients with AMI after PCI were analyzed via prospective studies. The reliability and validity of JHFRAS in the assessment of fall risk in patients with AMI

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Table 1. JHFRAS.

First part	Assessment standards	Second part	Scoring methods
Patients with coma or complete paralysis	Low risk	Age	60–69 years old = 1 point, 70–79 = 2 points, and ≥80 years old = 3 points
Fall ≥1 in front of the hospital within 6 months	High risk	Fall history	Unexplained falls lasting for 5 min in the last 6 months
Fall history during hospitalization		Defecation	Incontinence = 2 points, urgent and frequent voiding = 2 points, and urgent and frequent incontinence = 4 points
High fall risk in hospital		High-risk drug use	High-risk drug use = 3 points, 2 is 5 or more points, history is calm is 7 points within 24 h
		Stent number	1 = 1 point, 2 = 2 points, and ≥3 = 3 points
		Action capability	Assistance or supervision during mobility/transport or walking = 2 points, unsteady gait = 2 points, and mobility affected by visual or hearing impairment = 2 points
		Cognitive ability	Disorientation = 1 point, irritability = 2 points, limited cognition or disability = 4 points

JHFRAS, Johns Hopkins Fall Risk Assessment Scale.

after PCI are expected to guide clinical practice through the early identification of patients who may be at risk for falls in the clinic and taking steps to prevent fall events.

Objects and Methods

Research Objects

The subjects of this study were identified through the continuity inclusion of patients with AMI treated with PCI from January 2021 to December 2022 at our hospital. Patients were included if they (1) were diagnosed with AMI on the basis of symptoms in combination with electrocardiography and laboratory diagnosis; (2) were undergoing PCI surgery at our hospital; (3) had clear consciousness and good cooperation; and (4) did not experience fall injuries at 3 months postoperation. Patients were excluded if they had (1) serious complications, such as arrhythmia, heart failure, severe damage in liver and kidney function, and shock; (2) cardiac function level IV; (3) severe motor system diseases; and (4) cardiac tamponade, stent thrombosis, or hemodynamic fluctuations after intervention. This study was approved by the medical ethics committee of the hospital, and informed consent was obtained from patients.

Methods

Research Tools

JHFRAS

The content of JHFRAS is shown in Table 1. First, the patient was assessed in accordance with the first part of the scale or the second part of the scale if their condition was inconsistent with any of the items in the first part of the scale. The second part contained seven items, of which action capability and cognitive ability were multiple-choice and the rest were single-choice. This represented a score of 0 for this item. The second part utilized a three-point scale ranging from 0 to 35 (<6 points represent low risk, 6–13 points represent medium risk, and >13 points represent high risk). The assessment index of the content validity of the scale is represented by the content validity index (CVI). In this study, the CVI for each item (I-CVI) and for the whole scale (S-CVI) (>0.8 indicates that the scale has good content validity) must be calculated. Criterion-related validity refers to the correlation between the research instrument and other measurement criteria, with Spearman's correlation coefficient indicating the degree of correlation. Correlation coefficient r >0.7 indicates that the scale possesses favorable validity. Cronbach's α coefficient is commonly used to measure the internal consistency and reliability of measurement scales. Cronbach's α coefficient >0.8 indicates high reliability. The two-person evaluation of retest reliability utilized the Spearman rank correlation coefficient to calculate reliability.

General Information Questionnaire

The content of the independently designed questionnaire included gender; age; smoking history; drinking history; complications; heart function grading; infarction area; the time from onset to surgery; stent number; fall history; and the absence or presence of stroke as well as cataracts and other eye diseases.

Data Collection

Patients were independently assessed in accordance with the Chinese version of JHFRAS and general information questionnaire, and the assessment scores and related content were carefully recorded. Furthermore, expert evaluation was conducted to evaluate content validity, i.e., six experts in relevant fields were invited to evaluate the rele-

vance of the scale items to the research topic. The invitation criteria were as follows: (1) Experts who engage in or have been engaged in the clinical management and education of cardiovascular diseases for at least 5 years. (2) Experts with a university educational level or above. (3) Experts with intermediate or higher professional titles. (4) Experts with work seniority exceeding 10 years. (5) Experts with copious professional knowledge and rigorous academic attitudes.

Statistical Methods

Two people used Epodata3.1 software (The EpiData Association., Odense, Denmark) for data entry, and the data were checked at the same time to ensure their accuracy. SPSS22.0 (IBM Corp., Armonk, NY, USA) and Amos21.0 (IBM Corp., Armonk, NY, USA) were applied to analyze data. Count data were represented as [n (%)]. If sample size $\geq$40 and theoretical frequency T $\geq$5, the basic formula of the χ^2 test was applied with the test statistic of χ^2. If sample size $\geq$40 but theoretical frequency $1 \leq T < 5$, the χ^2 test correction formula was adopted. If sample size $<$40 or theoretical frequency T $<$1, Fisher's exact probability method for statistical analysis was used. Measurement information was first tested for conformity to normal distribution in accordance with the Shapiro–Wilk method. Measurement information that conformed to normal distribution was indicated as ($\bar{x} \pm s$) with the adoption of the *t*-test. Measurement information that did not conform to normal distribution was indicated as median and quartile [M(P25, P75)] with the adoption of the nonparametric test. The predictive value of the scale was assessed by using the area under the curve (AUC) of the receiver operator characteristic curve (ROC) with the determination of sensitivity, specificity, Jordon's index, and critical value. $p < 0.05$ was considered statistically significant.

Results

General Information of the Subjects

The characteristics of the enrolled patients are shown in Table 2.

Table 2. General information of 80 AMI cases after PCI.

Projects	Number of cases (case)	Proportion (%)
Gender		
Male	49	61.25
Female	31	38.75
Age		
$<$60 years old	65	81.25
$\geq$60 years old	15	18.75
Smoking history		
Yes	49	61.25
No	31	38.75
Drinking history		
Yes	30	37.50
No	50	62.50
Complications		
Hypertension	24	30.00
Diabetes	10	12.50
Hyperlipidemia	20	25.00
Heart function grading		
Level II	45	56.25
Level III	35	43.76
Infarction area		
Anterior wall	28	35.00
Lower wall	30	37.50
Anterior septum wall	22	27.50
Time from onset to surgery		
$<$3 h	68	85.00
$\geq$3 h	12	15.00
Number of stents		
1	36	45.00
2	34	42.50
$\geq$3	10	12.50
Fall history		
Yes	5	6.25
No	75	93.75
Stroke		
Yes	4	5.00
No	76	95.00
Cataract and other eye diseases		
Yes	6	7.50
No	74	92.50

AMI, acute myocardial infarction; PCI, percutaneous coronary intervention.

Comparison of the Fall and No-fall Groups of Post-PCI Patients with AMI

Through postoperative follow-up, this study found that among 80 patients with AMI after PCI, 11 cases experienced falls during out-of-bed activities and 69 cases did not experience falls. The general information of gender; age; smoking history; drinking history; complications; cardiac function grading; infarct area; time from onset to surgery; stent number; fall history; and existence of stroke, cataracts, and other eye diseases showed no statistically significant differences between the no-fall and fall groups ($p > 0.05$). However, JHFRAS scores showed a statistically significant difference ($p < 0.05$), as presented in Table 3.

Predictive Effect of JHFRAS for Fall Risk in Post-PCI Patients with AMI and Out-of-Bed Activities

Plotting the ROC curves revealed that in the prediction of the risk of falls in post-PCI patients with AMI and out-of-bed activities, JHFRAS had the AUC of 0.880, sensitivity

Table 3. Comparison of the general information and JHFRAS scale scores of the fall and no-fall groups of patients with AMI after PCI.

Projects	No-fall group (n = 69)	Fall group (n = 11)	χ^2/Z	*p*
Gender				
Male	42 (60.87)	7 (63.64)	0.025	0.874
Female	27 (39.13)	4 (35.36)		
Age				
<60 years	57 (82.61)	8 (72.73)	0.132	0.716
≥60 years	12 (17.39)	3 (27.27)		
Smoking history				
Yes	43 (62.32)	6 (54.55)	0.025	0.874
No	26 (37.68)	5 (45.45)		
Drinking history				
Yes	26 (37.68)	4 (36.36)	0.063	0.801
No	43 (62.32)	7 (63.64)		
Complications				
High blood pressure	21 (30.43)	3 (27.27)	0.020	0.887
Diabetes	9 (13.04)	1 (9.09)	0.015	0.902
High blood fat disease	18 (26.09)	2 (18.18)	0.002	0.966
Cardiac function grading				
Grade 2	39 (56.52)	6 (54.55)	0.042	0.838
Grade 3	30 (43.48)	5 (45.45)		
Infarct area				
Front wall	24 (34.78)	4 (36.36)		
Lower wall	25 (36.23)	5 (45.45)	0.625	0.732
Anterior wall of the nasal septum	20 (28.99)	2 (18.18)		
Time from onset to surgery				
<3 h	59 (85.51)	9 (81.82)	0.019	0.892
≥3 h	10 (14.49)	2 (18.18)		
Stent number				
1	30 (43.48)	6 (54.55)		
2	30 (43.48)	4 (36.36)	0.490	0.783
≥3	9 (13.04)	1 (9.09)		
Fall history				
Yes	4 (5.80)	1 (9.09)	-	0.533*
No	65 (94.20)	10 (90.91)		
Stroke				
Yes	3 (4.35)	1 (9.09)	-	0.453*
No	66 (95.65)	10 (90.91)		
Cataracts and other eye diseases				
Yes	5 (7.25)	1 (9.09)		
No	64 (92.75)	10 (90.91)		
JHFRAS (points)	8.00 (7.00,10.00)	13.00 (11.50,15.50)	4.931	<0.001

Note: * indicates Fisher's exact probability method; JHFRAS, Johns Hopkins Fall Risk Assessment Scale.

of 0.937, specificity of 0.824, and Jordon's index of 0.760 with a critical value of 9, as shown in Fig. 1.

Scale Reliability

Reliability of Internal Consistency

Cronbach's α coefficient was used to evaluate the internal consistency of the scale. Given that the first part of the scale did not require scoring, fall risk could be directly classified on the basis of a patient's condition. Therefore, Cronbach's α coefficient was not used for evaluation. The second part of the scale consisted of seven items with a Cronbach's α coefficient of 0.803. Table 4 shows the Cronbach's α coefficient of each item.

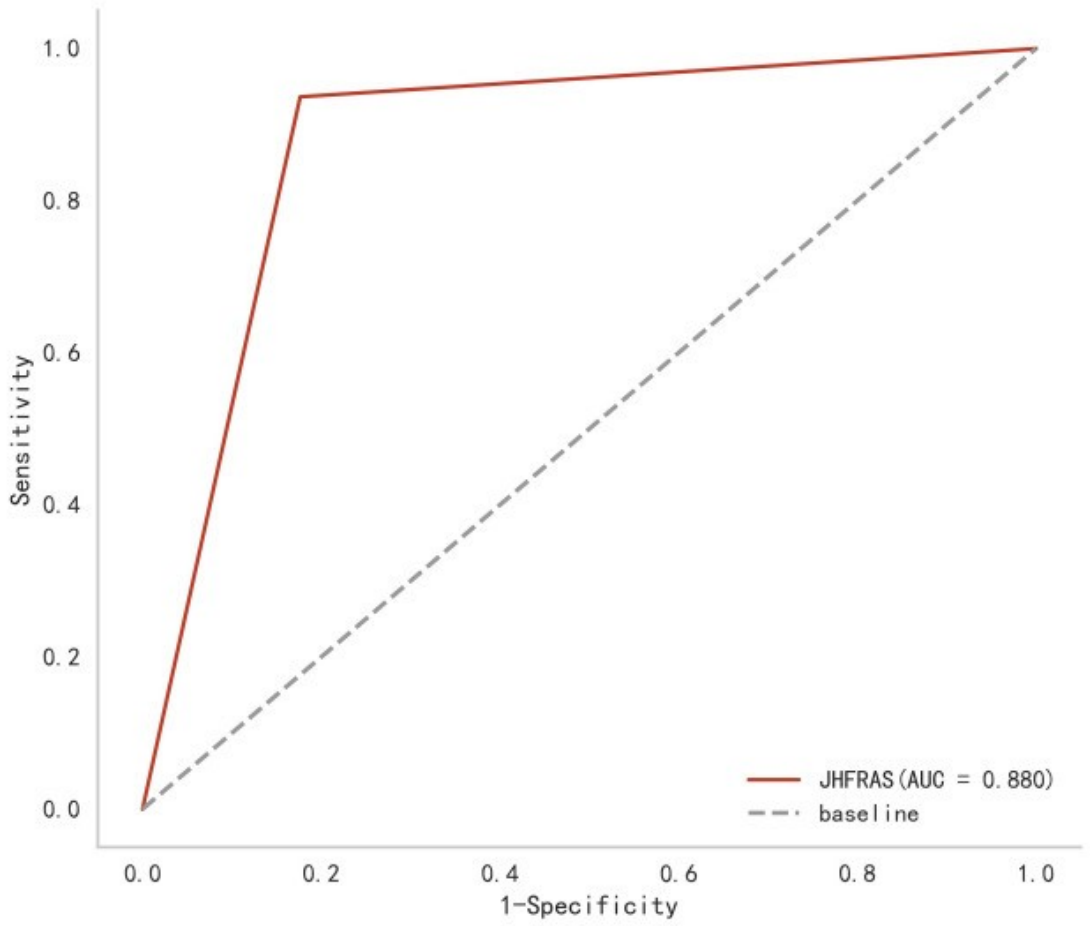

Fig. 1. Receiver operator characteristic (ROC) curves of JHFRAS in the prediction of fall risk in post-PCI patients with AMI and out-of-bed activities.

Table 4. Cronbach's α coefficients for scales.

Projects	Cronbach's α coefficient
Age	0.875
Fall history	0.860
Defecation	0.838
High-risk drug use	0.850
Stent number	0.846
Action capability	0.875
Cognitive ability	0.826

Table 5. CVIs of the scale.

Projects	CVI
Age	0.915
Fall history	0.924
Defecation	0.938
High-risk drug use	0.920
Stent number	0.954
Action capability	0.960
Cognitive ability	0.972

CVI, content validity index.

Interrater Reliability

A total of 80 patients with AMI undergoing PCI were independently evaluated by two reviewers at the same time. The reviewers were unaware of the content and results of the review. The evaluation data from two reviewers were analyzed by intragroup coefficient analysis. The Spearman rank correlation coefficient was r = 0.948.

Validity of the Scale

Content Validity

In this study, the CVI of the scale was evaluated through expert evaluation. Four quality control experts in the fall aspect, including two chief superintendent nurses and two cochief superintendent nurses, were selected to evaluate each item of the questionnaire in accordance with four-level scoring (strongly agree, agree, disagree and strongly disagree). Meanwhile, opinions were given on whether an item content was consistent with Chinese culture, whether an item was reasonable, and whether adding an item content was necessary. The overall CVI of the scale

Table 6. Spearman's correlation analysis of each dimension and total scores of rMFS and JHFRAS.

	Materiality	Validity	Dependability	Communicative	Empathy	JHFRAS
rMFS	0.335	0.470	0.420	0.545	0.668	0.652

rMFS, revised Morse fall assessment scale.

was 0.968. The specific CVIs of age, fall history, urine and defecation excretion amount, high-risk drug use, stent number, action capability, and cognitive ability are shown in Table 5.

Criterion-related Validity

In this study, the revised Morse fall assessment scale (rMFS) score was used as the criterion-related validity index. Two researchers used rMFS and JHFRAS to assess patients independently and simultaneously. The results are provided in Table 6. All correlation coefficients reached significance at the 0.01 level. The score of each dimension of rMFS and JHFRAS was positively correlated.

Discussion

Reliability of the Scale

Reliability is mainly used to evaluate the accuracy, stability, and consistency of scales. The common indicators used to evaluate reliability include test-retest, split-half, interrater, and internal consistency reliabilities [11–13]. Interrater reliability refers to the consistency of different reviewers in judging the same object [14–16]. A scale has good reliability and high stability when the correlation coefficient r of two results exceeds 0.7 [17]. In this study, 80 patients with AMI undergoing PCI were independently evaluated by two reviewers at the same time. The intragroup coefficient analysis of the two reviewers' assessment data yielded a Spearman rank correlation coefficient of r = 0.948, suggesting that the scale can be used for risk assessment and the assessment results among different reviewers are highly consistent. The Cronbach's α coefficient for the second part of the scale, which contains seven items, was 0.803, indicating that the reliability coefficient was satisfactory and the scale had good internal consistency. In contrast to the present study, the work of Hnizdo *et al*. [18] obtained a Cronbach's α coefficient of 0.703 for the fall risk assessment scale. This difference was likely due to the different application objects of the scale.

Scale Validity Analysis

Validity is mainly used to evaluate the accuracy and validity of scales, and common evaluation indicators include calibration association, structure, and content validities [19,20]. CVI ranges from 0 to 1, and a high value is indicative of the good representativeness and suitability of the items of the scale [21]. Usually, a CVI exceeding 0.8 is acceptable [22,23]. The overall CVI of the scale was 0.968, and the CVIs for age, fall history, urine and defecation excretion amount, high-risk drug use, stent number, action capability, and cognitive ability were 0.915, 0.924, 0.938, 0.920, 0.954, 0.960, and 0.972, respectively. The content validity was good in accordance with expert evaluation. The rMFS score was used as the criterion-related validity index, and rMFS and JHFRAS were independently used by two reviewers to evaluate patients at the same time. All correlation coefficients reached significance at the 0.01 level, and the score of each dimension in rMFS and JHFRAS was positively correlated. JHFRAS has good criterion-related validity. The structural validity of the scale was not analyzed in this study given the absence of a developer to differentiate the dimensions of the original scale. Therefore, an exploratory factor analysis could not be conducted.

Predictive Effectiveness and Precautions of Scales for Fall Risk in Post-PCI Patients with AMI and Out-of-Bed Activities

Postoperative follow-up revealed that among the 80 post-PCI patients with AMI, 11 cases experienced falls during out-of-bed activities and 69 cases did not experience falls. JHFRAS scores significantly differed between these two groups ($p < 0.05$). Further plotting the ROC curve revealed that the AUC of JHFRAS for the prediction of the risk of falls during out-of-bed activities in post-PCI patients with AMI was 0.880, which indicated that the predictive value of JHFRAS for the risk of falls during out-of-bed activities in post-PCI patients with AMI was high.

JHFRAS can be divided into two parts. The first part evaluates fall risk on the basis of the actual situations of patients; the medical staff then takes relevant intervention measures in accordance with classification results, which are rapid, time-saving, and objective [24,25]. Low-risk safety interventions are given to patients with complete paralysis or mobility impairment. Patients with number of falls $\geq$1 in front of the hospital within 6 months or who experienced falls during hospitalization receive safety interventions on the basis of their high risk in the hospital. For patients with a history of falls within 6 months, interventions are given on the basis of their high risk levels [5]. All items were assessed in the first part only if the second part is not met, and the item is objective, requiring nurses to clarify the risk level and implement intervention at the same time on the basis of subjective evaluation [26]. During the evaluation of the scales in the second part, special attention should be paid to single- and multiple-choice questions

in the main scoring options, which should be distinguished when calculating the final score [27,28].

This study still has some deficiencies. First, the patients were admitted to our hospital during a specific period, and the inclusion of a small sample size resulted in sample limitations. In addition, the specificity of our hospital, as the center of this study, restricts the generalizability of the findings to other healthcare organizations with different backgrounds and clinical practices. Finally, the questionnaire involved in this study lacked scale questions and therefore could not be analyzed for structural validity. Future research could compensate for these limitations with a refined design and a multicenter study with a large sample.

Conclusions

JHFRAS has good reliability and validity and can thus be used for fall risk assessment during walking among patients with AMI after PCI. However, this study still has limitations, such as its small sample size and singular sample source. Moreover, the scale was applied to a single population. This characteristic needs to be improved in the future to further demonstrate the above conclusions and guide clinical practice.

Availability of Data and Materials

The original contributions to the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding authors.

Author Contributions

JY: conception, design, materials, data collection, analysis, literature review, and writing. JZ: design, supervision, materials, data collection, analysis, literature review, and writing. Both authors contributed to editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the Medical Ethics Committee of Wenzhou Central Hospital with the approval no. 2020-04-002. All participants signed an informed consent form.

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Conflict of Interest

The authors declare no conflict of interest.

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