Development and Validation of a Predictive Model for Poor Healing After Great Saphenous Vein Stripping in Patients With Varicose Ulcers: Focusing on Preoperative Iron Metabolism Markers

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AIM: To develop and validate a nomogram for predicting the risk of poor healing after great saphenous vein stripping in patients with venous varicose ulcers, based on preoperative iron metabolism markers and other clinical indicators.

METHODS: Clinical data from 278 patients with venous varicose ulcers who underwent great saphenous vein stripping at Wujin Hospital Affiliated with Jiangsu University between July 2022 and January 2025 were retrospectively analyzed. Patients were randomly divided to a training set (n = 166) and a validation set (n = 112) at a 6:4 ratio. Based on the ulcer healing status at 6 months postoperatively, patients were categorized into a poor healing group and a good healing group. Univariate and multivariate logistic regression analyses were performed to identify independent risk factors for postoperative poor healing, and a nomogram prediction model was developed based on these factors. Internal validation of model performance was conducted using the Bootstrap resampling method. Model discrimination, calibration, and clinical utility were evaluated using the receiver operating characteristic (ROC) curve, calibration curve, and decision curve analysis (DCA), respectively.

RESULTS: The overall incidence of postoperative poor healing was 40.29% (112/278). Multivariate logistic regression analysis revealed that diabetes (odds ratio [OR] = 3.01, 95% confidence interval [CI]: 1.38–6.57), increased soluble transferrin receptor (sTfR) (OR = 1.78, 95% CI: 1.17–2.70), decreased albumin (OR = 0.92, 95% CI: 0.85–0.99), and elevated C-reactive protein (CRP) (OR = 1.05, 95% CI: 1.02–1.08) were independent risk factors for postoperative poor healing (all $p < 0.05$). The nomogram model based on these factors yielded an area under the curve (AUC) of 0.75 (95% CI: 0.68–0.83) in the training set and 0.74 (95% CI: 0.64–0.83) in the validation set. Calibration curves demonstrated good agreement between predicted and observed probabilities. Decision curve analysis indicated a favorable clinical net benefit of the model.

CONCLUSIONS: The prediction model developed in this study effectively assesses the risk of poor healing after great saphenous vein stripping in patients with venous varicose ulcers, facilitating early identification of high-risk patients and supporting targeted clinical interventions.

Keywords: varicose ulcer; wound healing; iron metabolism markers; risk prediction; nomogram

Introduction

Chronic venous disease represents a major global health concern, with its most severe manifestation, active venous leg ulcers (VLUs), significantly impairing the quality of life of patients and constituting a major socioeconomic burden [1,2]. Venous ulcers (Clinical Etiologic Anatomic Pathophysiologic Classification, Class 6 (Active Venous Ulcer) [CEAP C6 class]) are characterized by a prolonged disease course, frequent recurrence, even with standardized compression therapy, and a considerable proportion of patients fail to achieve satisfactory wound closure [2]. Notably, poor postoperative healing in these patients extends beyond ulcer persistence alone. It is associated with an increased risk of wound infection, cellulitis, and osteomyelitis, often necessitating prolonged systemic antibiotic therapy or surgical debridement [3,4]. The resulting chronic pain, excessive exudate, and malodor significantly impair mobility, sleep quality, and psychosocial well-being, often leading to social withdrawal and depressive symptoms [5,6]. From a healthcare system perspective, non-healing ulcers substantially increase economic burden through extended outpatient management, advanced wound care requirements, and elevated hospital readmission rates [7]. Most critically, delayed or failed healing is a strong predictor of ulcer recurrence, perpetuating a cycle of chronic morbidity.

In patients with venous ulcers associated with definite superficial venous reflux, venous ablation procedures, including stripping of the great saphenous vein, have become es-

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tablished treatment options. High-quality randomized controlled trials, most notably the Early Venous Reflux Ablation (EVRA) trial, have demonstrated that early closure of refluxing superficial veins significantly accelerates ulcer healing and reduces recurrence [8]. Currently, factors influencing postoperative healing of venous ulcers have been extensively explored. Numerous clinical variables associated with impaired healing have been identified, including advanced age, large ulcer size, long ulcer duration, coexisting deep venous insufficiency, bacterial colonization or infection, and compromised nutritional status [9]. However, most of these traditional clinical factors are largely determined preoperatively and are challenging to modify, thereby limiting their potential application in individualized risk stratification and preoperative optimization. Consequently, identifying novel, objective biomarkers that can be assessed preoperatively and are potentially modifiable has become an important research priority in this field.

Among emerging biomarkers, indicators of iron metabolism have attracted increasing attention. Iron is an essential trace element required for cellular proliferation, energy metabolism, and immune function, and it plays a central role throughout all stages of wound healing, including inflammation, tissue proliferation, and extracellular matrix remodeling [10,11]. Recent evidence suggests that iron homeostasis is crucial for coordinating immune responses within the wound microenvironment, particularly by regulating macrophage polarization toward a pro-repair phenotype [12]. Moreover, iron is an essential cofactor for collagen-synthesizing enzymes, such as prolyl hydroxylase and lysyl hydroxylase. Iron deficiency directly impairs fibroblast function and collagen maturation, leading to inadequate granulation tissue formation and delayed re-epithelialization [13]. Furthermore, iron metabolism is closely linked to systemic inflammatory and immune pathways, and disturbances in iron homeostasis may disrupt the delicate balance between inflammation and tissue repair by altering macrophage polarization [14]. Although iron deficiency and anemia of chronic disease have been associated with delayed healing in other chronic wound types, including pressure ulcers and diabetic foot ulcers [15,16], robust evidence specifically focusing on the association between preoperative iron status and postoperative healing outcomes in patients with venous ulcers remains limited. Existing studies have predominantly focused on general nutritional or inflammatory indicators, while relatively neglecting iron metabolism as a distinct, quantifiable, and potentially modifiable physiological pathway.

Therefore, the present study focuses on evaluating preoperative iron metabolism markers, including ferritin, total iron-binding capacity (TIBC), transferrin saturation (TSAT), and soluble transferrin receptor (sTfR), for predicting poor healing following great saphenous vein stripping. Additionally, we aimed to develop and validate a visual nomogram-based prediction model to facilitate early risk assessment and to provide an evidence-based rationale for targeted preoperative interventions, such as iron supplementation or nutritional support, with the potential to improve postoperative healing outcomes.

Methods

Study Population

This retrospective study consecutively collected clinical data from 278 patients with venous varicose ulcers who underwent great saphenous vein stripping at Wujin Hospital Affiliated with Jiangsu University between July 2022 and January 2025. The inclusion criteria were as follows: (1) diagnosis of lower extremity venous ulcer classified as Clinical Etiologic Anatomic Pathophysiologic Classification, Class 6 (Active Venous Ulcer) (CEAP C6); (2) first-time unilateral great saphenous vein high ligation and stripping; (3) complete assessment of iron metabolism indicators within 2 weeks preoperatively; (4) availability of complete clinical data. The exclusion criteria were: (1) comorbid conditions known to affect wound healing, including arterial ulcers, diabetic foot ulcers, or rheumatic immune diseases; (2) long-term oral or intravenous iron therapy before surgery; (3) lost to follow-up or incomplete follow-up data.

The sample size for this retrospective study was determined by the availability of all consecutive eligible patients during the study period, as a formal prospective sample size calculation was not performed for this hypothesis-generating model development study. The final cohort consisted of 278 patients with 112 poor-healing events, which satisfied the commonly accepted rule of thumb for logistic regression analysis, recommending a minimum of 10 events per predictor variable.

This study was approved by the Ethics Committee of Wujin Hospital Affiliated with Jiangsu University (approval number: 2025-SR-413). Due to the retrospective design, the requirement for informed consent was waived in accordance with national regulations and institutional guidelines. All study procedures followed the ethical principles outlined in the Declaration of Helsinki.

Data Collection

First, the entire cohort of 278 patients was randomly divided into a training set (n = 166) and a validation set (n = 112) in a 6:4 ratio for model development and internal validation, respectively. Postoperative ulcer healing status (good or poor) was subsequently determined for each patient based on the 6-month follow-up results according to predefined criteria. This allocation ratio was selected because it is commonly applied in predictive modeling to ensure an adequate sample size for model training while retaining sufficient data for validation. The following demographic, clinical, and laboratory variables were collected: age (years), sex, history of diabetes, ulcer duration

Table 1. Baseline characteristics of patients in the training and validation sets.

Variables	Total (n = 278)	Validation set (n = 112)	Training set (n = 166)	Statistic	*p*-value
TIBC (μmol/L), mean ± SD	62.59 ± 7.37	62.81 ± 6.99	62.44 ± 7.63	$t = 0.41$	0.679
sTfR (mg/L), mean ± SD	3.02 ± 0.83	3.00 ± 0.76	3.03 ± 0.87	$t = –0.37$	0.711
Age (years), median (Q_1, Q_3)	64.00 (59.00, 71.00)	64.50 (59.00, 72.25)	64.00 (59.00, 70.00)	Z = –0.46	0.644
Ulcer duration (months), median (Q_1, Q_3)	18.00 (9.25, 25.75)	18.00 (8.00, 26.00)	18.00 (10.00, 25.00)	Z = –0.20	0.845
Initial ulcer area (cm^2), median (Q_1, Q_3)	5.20 (3.12, 7.88)	5.40 (3.08, 8.88)	5.10 (3.20, 7.30)	Z = –0.67	0.506
Villalta score, median (Q_1, Q_3)	16.00 (13.00, 18.00)	16.00 (13.00, 18.00)	16.00 (13.25, 18.00)	Z = –0.18	0.854
Ferritin (μg/L), median (Q_1, Q_3)	121.50 (72.00, 203.00)	127.50 (81.00, 196.50)	117.00 (69.75, 205.25)	Z = –0.84	0.401
Albumin (g/L), median (Q_1, Q_3)	36.90 (34.12, 40.50)	37.60 (34.38, 40.82)	36.80 (34.10, 40.48)	Z = –0.68	0.499
CRP (mg/L), median (Q_1, Q_3)	9.75 (6.00, 17.20)	9.85 (5.85, 17.33)	9.65 (6.10, 16.80)	Z = –0.10	0.918
Transferrin saturation (percentage), median (Q_1, Q_3)	25.55 (19.10, 31.55)	25.90 (19.60, 31.93)	25.10 (18.65, 30.80)	Z = –0.82	0.412
Gender, n (%)				$\chi^2 = 1.18$	0.277
Female	128 (46.04)	56 (50.00)	72 (43.37)		
Male	150 (53.96)	56 (50.00)	94 (56.63)		
Diabetes, n (%)				$\chi^2 = 0.08$	0.777
No	211 (75.90)	86 (76.79)	125 (75.30)		
Yes	67 (24.10)	26 (23.21)	41 (24.70)		
Compression therapy compliance, n (%)				$\chi^2 = 1.42$	0.233
Fair	177 (63.67)	76 (67.86)	101 (60.84)		
Good	101 (36.33)	36 (32.14)	65 (39.16)		
Healing status, n (%)				$\chi^2 = 0.28$	0.597
Good	166 (59.71)	69 (61.61)	97 (58.43)		
Poor	112 (40.29)	43 (38.39)	69 (41.57)		

Note: TIBC, total iron-binding capacity; sTfR, soluble transferrin receptor; CRP, C-reactive protein.

(months), initial ulcer area (cm^2), Villalta score (range 0–33, with higher scores indicating greater disease severity), ferritin (μg/L), total iron-binding capacity (TIBC, μmol/L), transferrin saturation (TSAT, %), soluble transferrin receptor (sTfR, mg/L), serum albumin (g/L), C-reactive protein (CRP, mg/L), and compliance with compression therapy. Compression therapy compliance was categorized as good (medical records explicitly stated "patient reported daily adherence" or "good compliance") or fair (records indicated "patient reported incomplete adherence"). Iron metabolism indicators were measured from fasting venous blood samples collected in the morning within 2 weeks before surgery.

Statistical Methods

Statistical analyses were performed using R software (version 4.3.3, R Foundation for Statistical Computing, Vienna, Austria). Continuous variables are presented as mean ± standard deviation for normally distributed data, as assessed by the Shapiro-Wilk test, or as median (first quartile, third quartile) [M (Q_1, Q_3)] for non-normally distributed data. Categorical variables are presented as frequency and percentage [n (%)]. Due to the strict inclusion criteria requiring complete datasets, no variables had missing values for analysis.

Variables with a p-value < 0.1 in univariate analysis were included as candidates for multivariate logistic regression analysis. Before multivariable modeling, variance inflation factors (VIFs) were calculated to evaluate multicollinearity, with all VIF values <5. A bidirectional stepwise selection procedure based on the Akaike Information Criterion (AIC) was applied to derive the final multivariate model.

Internal validation was performed using the Bootstrap resampling method with 1000 iterations. Model discrimination was evaluated using receiver operating characteristic (ROC) curves, calibration was assessed using calibration plots and the Hosmer-Lemeshow goodness-of-fit test, and clinical utility was evaluated using DCA curves. A two-sided p-value < 0.05 was considered statistically significant.

Results

Comparison Between the Training Set and Validation Set

This study included a total of 278 patients with venous varicose ulcers (CEAP C6 class) who underwent stripping of the great saphenous vein. Patients were randomly allocated to a training set (n = 166) and a validation set (n = 112) at a 6:4 ratio. No statistically significant differences were observed between the training and validation sets in terms of demographic characteristics, ulcer-related variables, venous functional severity (Villalta score), laboratory indicators (including iron metabolism, nutritional, and inflammatory markers), or postoperative compression therapy compliance (all $p > 0.05$), indicating well-balanced baseline characteristics and comparability between the two groups (Table 1). The overall incidence of postoperative poor healing in the entire cohort was 40.29% (112/278).

Table 2. Univariate logistic regression analysis of factors associated with postoperative healing.

Variables	β	SE	Z	p-value	OR (95% CI)
Gender					
Female					1.00
Male	–0.01	0.32	–0.02	0.982	0.99 (0.53–1.85)
Diabetes					
No					1.00
Yes	1.06	0.37	2.85	0.004	2.88 (1.39–5.95)
Compression therapy compliance					
Fair					1.00
Good	–0.11	0.32	–0.33	0.743	0.90 (0.48–1.69)
Age	0.02	0.02	1.35	0.178	1.02 (0.99–1.06)
Ulcer duration	0.00	0.01	0.31	0.753	1.00 (0.98–1.03)
Initial ulcer area	–0.03	0.03	–0.92	0.357	0.97 (0.91–1.03)
Villalta score	0.07	0.05	1.52	0.129	1.08 (0.98–1.18)
Ferritin	–0.00	0.00	–0.86	0.389	1.00 (1.00–1.00)
TIBC	–0.02	0.02	–0.78	0.438	0.98 (0.94–1.02)
Albumin	–0.10	0.04	–2.75	0.006	0.90 (0.84–0.97)
sTfR	0.52	0.19	2.71	0.007	1.68 (1.15–2.46)
CRP	0.04	0.01	3.04	0.002	1.05 (1.02–1.08)
Transferrin saturation	–0.03	0.02	–1.97	0.049	0.97 (0.94–0.99)

Notes: OR, odds ratio; CI, confidence interval; SE, standard error; TIBC, total iron-binding capacity; sTfR, soluble transferrin receptor; CRP, C-reactive protein.

Table 3. Multivariate logistic regression analysis of independent risk factors for postoperative poor healing.

Variables	β	SE	Z	p-value	OR (95% CI)
Diabetes					
No					1.00
Yes	1.10	0.40	2.77	0.006	3.01 (1.38–6.57)
sTfR	0.58	0.21	2.71	0.007	1.78 (1.17–2.70)
Albumin	–0.08	0.04	–2.00	0.046	0.92 (0.85–0.99)
CRP	0.05	0.02	3.23	0.001	1.05 (1.02–1.08)

Notes: OR, odds ratio; CI, confidence interval; sTfR, soluble transferrin receptor; CRP, C-reactive protein.

Univariate Analysis

Univariate logistic regression analysis demonstrated that diabetes, elevated sTfR, decreased albumin, elevated CRP, and decreased transferrin saturation were significantly associated with poor postoperative healing (all $p < 0.05$). In contrast, sex, age, compliance with compression therapy, ulcer duration, initial ulcer area, Villalta score, ferritin, and TIBC were not significantly associated with healing outcomes (Table 2).

Multivariate Analysis

Based on stepwise regression analysis ($p < 0.05$), four variables were retained in the final multivariate model: diabetes, sTfR, albumin, and CRP. Multivariate logistic regression confirmed that diabetes (odds ratio [OR] = 3.01, 95% confidence interval [CI]: 1.38–6.57), elevated sTfR (OR = 1.78, 95% CI: 1.17–2.70), decreased albumin (OR = 0.92, 95% CI: 0.85–0.99), and elevated CRP (OR = 1.05, 95% CI: 1.02–1.08) were independent risk factors for poor healing after great saphenous vein stripping in patients with venous varicose ulcers (all $p < 0.05$) (Table 3).

Nomogram Construction

Based on the four independent risk factors identified above, a logistic regression-based prediction model for postoperative poor healing was developed, and a visual nomogram was constructed (Fig. 1). Using this nomogram, clinicians can estimate an individual patient's total score according to diabetes status and the measured values of sTfR, albumin, and CRP, thereby visually assessing the individualized probability of postoperative poor healing.

Receiver Operating Characteristic Curve

The discriminative performance of the prediction model was evaluated using the receiver operating characteristic (ROC) curve. In the training set, the area under the curve (AUC) was 0.75 (95% CI: 0.68–0.83), while in the validation set, the AUC was 0.74 (95% CI: 0.64–0.83) (Fig. 2). These results indicate that the model demonstrates good discriminative potential and can effectively distinguish between patients with good and poor postoperative healing outcomes.

Calibration Curve

The predictive accuracy of the model was evaluated using calibration curves and the Hosmer-Lemeshow goodness-of-fit test. As shown in Fig. 3, the calibration curves for

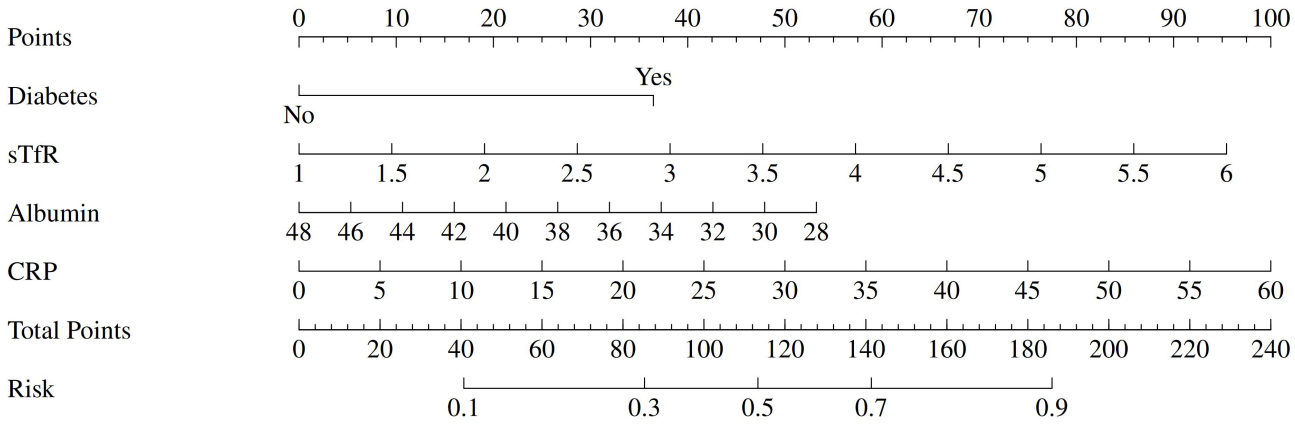

Fig. 1. Nomogram for predicting poor postoperative healing.

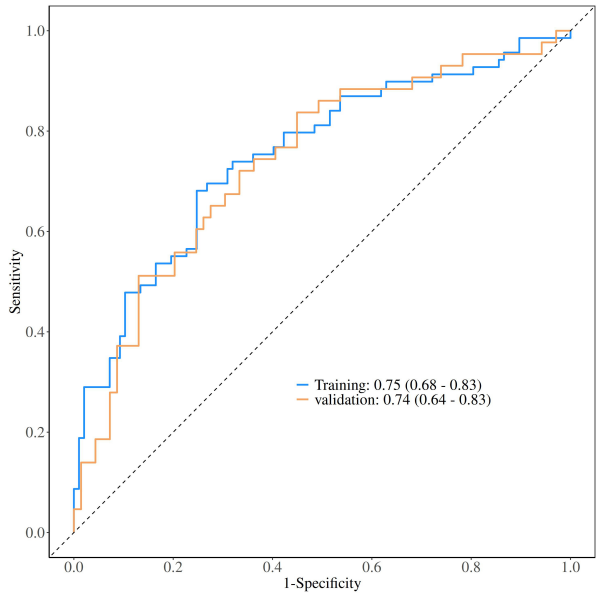

Fig. 2. Receiver operating characteristic (ROC) curves of the prediction model.

both the training set (A) and validation set (B) demonstrated close agreement between the model-predicted probabilities ("Apparent" and "Bias-corrected") and the ideal reference line ("Ideal"). The Hosmer-Lemeshow test further supported the excellent calibration of the model, with *p*-values of 0.568 for the training set and 0.893 for the validation set, both exceeding the 0.05 threshold. These findings indicate no significant difference between predicted and observed outcomes, demonstrating good consistency of the model.

Decision Curve Analysis

Decision curve analysis (DCA) demonstrated that in both the training (A) and validation (B) sets, when the threshold probability ranged from 0.2 to 0.7, the net benefit of applying the prediction model for clinical decision-making was higher than that of the two extreme strategies of "treat all" and "treat none" (Fig. 4). These findings suggest that the model has a broad and favorable range of clinical applicability and can provide meaningful support for informed clinical decision-making.

Discussion

Using a retrospective cohort design and multivariate analysis, this study systematically examined the impact of preoperative variables such as iron metabolism markers on poor healing after great saphenous vein stripping in patients with venous varicose ulcers. The findings demonstrated that among the evaluated iron metabolism indicators, soluble transferrin receptor (sTfR) emerged as an independent predictor of poor postoperative healing. The nomogram model constructed using four variables, sTfR, diabetes, albumin, and CRP, showed stable performance in internal validation, with good discriminative ability, excellent calibration, and clear clinical applicability.

The key contribution of this study is the extension of postoperative healing risk assessment from conventional clinical factors to the level of tissue iron metabolism. The superior predictive value of sTfR compared with conventional indicators, such as ferritin and transferrin saturation, can be attributed to its unique biological characteristics. sTfR is primarily derived from the shedding of transferrin receptors on actively proliferating cells, and its elevation directly indicates insufficient iron supply at the tissue level relative to the demands of repair processes [17]. Unlike ferritin, which is easily influenced by inflammatory status, sTfR more accurately reflects the functional iron requirements of repair-related cells, including fibroblasts, within the local ulcer microenvironment [18,19]. This interpretation is supported by emerging clinical evidence that identifies sTfR as a robust biomarker of functional iron deficiency, even in the presence of systemic inflammation, outperforming conventional storage-based iron parameters [20]. Accordingly, sTfR may serve as a reliable indicator for identifying patients with tissue-level iron deficiency, and its predictive significance surpasses that of traditional markers that primarily reflect iron stores.

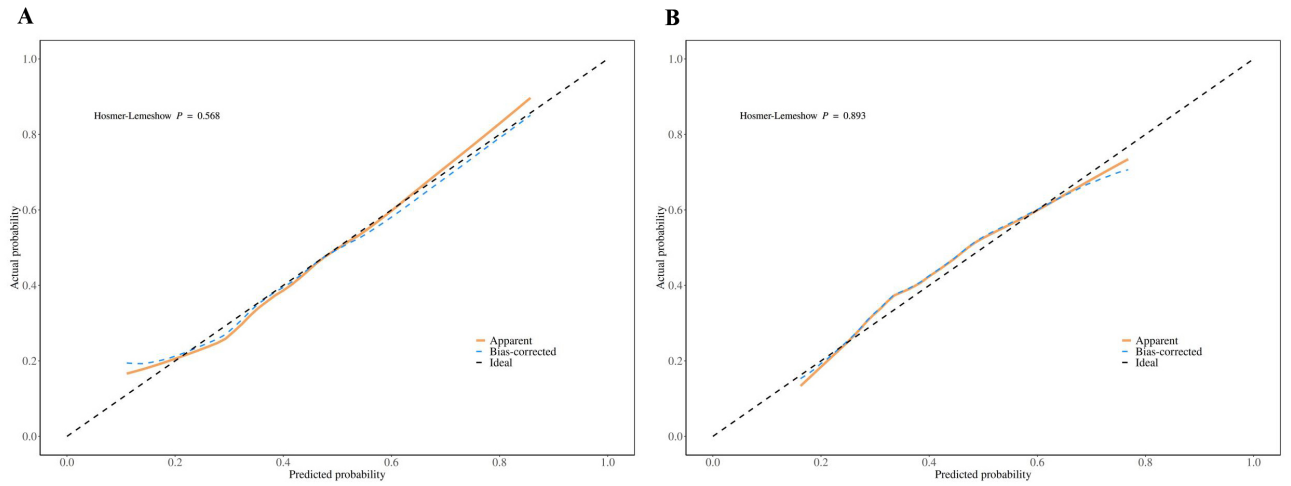

Fig. 3. Calibration curves of the prediction model in the training and validation cohorts. (A) Calibration curves of the prediction model in the training cohort. (B) Calibration curves of the prediction model in the validation cohort.

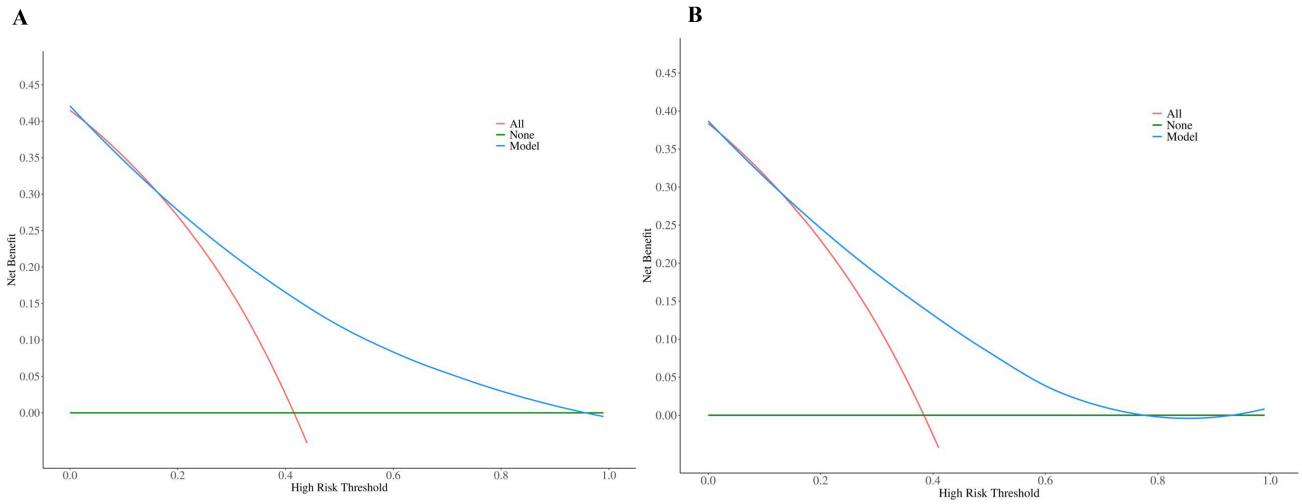

Fig. 4. Decision curve analysis of the prediction model in the training and validation cohorts. (A) Decision curve analysis of the prediction model in the training cohort. (B) Decision curve analysis of the prediction model in the validation cohort.

The identified predictors, including diabetes, albumin, CRP, and sTfR, interact across key pathophysiological axes that critically influence wound healing. Diabetes impairs microcirculation and immune cell function through mechanisms that include the accumulation of advanced glycation end-products and oxidative stress. Hypoalbuminemia reduces colloid osmotic pressure, thereby exacerbating local tissue edema, and limits the availability of essential substrates for collagen biosynthesis. Elevated CRP, as a marker of systemic inflammation, reflects an inflammatory milieu that can activate proteolytic enzymes, degrade extracellular matrix components, and hinder the migration of reparative cells. Elevated sTfR levels indicate that tissue-level iron demand exceeds supply, directly impairing iron-dependent enzymatic processes required for fibroblast proliferation and collagen maturation.

The prediction model developed in this study integrates three interrelated pathophysiological dimensions that collectively define the core mechanistic network underlying postoperative healing. Specifically, sTfR represents whether the adequacy of microscopic enzymatic "tools" required for tissue repair is available, albumin reflects the adequacy of macroscopic nutritional "raw materials" for new tissue synthesis, and CRP indicates whether the systemic inflammatory environment is conducive to repair. These factors form a vicious cycle: systemic inflammation can simultaneously induce functional iron deficiency and nutritional depletion, while malnutrition further amplifies inflammatory responses and delays wound healing [21–23]. This complex interplay is consistent with composite clinical indices that integrate inflammatory and nutritional parameters, which have been shown to predict healing outcomes in chronic wounds [24].

Unlike previous studies that predominantly focused on ulcer-related characteristics or conventional clinical variables [25,26], the novelty of the present study lies in the systematic evaluation of preoperative systemic iron metabolism markers in a surgical venous ulcer population. While Pihlaja *et al*. [25] identified deep venous insufficiency and larger ulcer area as major risk factors, and Gohel *et al*. [26] emphasized ulcer duration, our model introduces sTfR as a novel and biologically informative biomarker. This shifts the assessment paradigm from simply identifying "anemia" to evaluating "tissue iron availability", thereby offering a new mechanistic perspective on impaired wound healing.

The clinical value of this model lies primarily in its potential for intervention. Elevated sTfR provides a basis for targeted preoperative iron supplementation, hypoalbuminemia highlights the need for nutritional optimization, and increased CRP suggests that modulation of systemic inflammation may be warranted. Therefore, this model functions not only as an early-warning system for poor healing risk but also as a practical framework for preoperative optimization, guiding the implementation of individualized, multimodal prehabilitation measures in high-risk patients, with the potential to improve surgical outcomes.

Several limitations of this study should be acknowledged. First, the single-center retrospective design may introduce selection bias. Second, the model was developed and internally validated only; external validation in independent, multicenter, prospective cohorts is essential to confirm its reliability and generalizability before widespread clinical application. Third, patients receiving preoperative iron supplementation were excluded, which may limit the applicability of the model to this specific subgroup. Future research should focus on expanding sample size for external validation; conducting interventional studies to determine whether model-guided preoperative management (e.g., iron supplementation) improves healing outcomes, and further refining the prediction system by incorporating indicators of the local wound microenvironment.

Conclusions

In conclusion, this study developed and internally validated a nomogram for predicting the risk of poor healing after great saphenous vein stripping in patients with venous ulcers. The model incorporates diabetes, sTfR, albumin, and CRP, variables that collectively reflect interconnected pathophysiological processes involving tissue iron utilization, nutritional status, and systemic inflammation. Among these, sTfR, an indicator of tissue iron demand, demonstrated independent predictive value alongside traditional clinical indicators, including diabetes, albumin, and CRP. This nomogram provides a practical tool for preoperative risk stratification and provides a framework for hypothesis-driven investigations into targeted prehabilitation strategies, such as iron supplementation and nutritional optimization. Future multicenter prospective studies are warranted to externally validate this model and to determine whether model-guided interventions can meaningfully improve postoperative healing outcomes.

Availability of Data and Materials

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

Author Contributions

YZ and XRZ designed the research study. YZ and TQ performed the research. YZ and XRZ analyzed the data. TQ drafted the article. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Wujin Hospital Affiliated with Jiangsu University (approval number: 2025-SR-413), and all procedures followed the principles of the Declaration of Helsinki. Due to the retrospective design, the requirement for informed consent was waived in accordance with national regulations and institutional guidelines.

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Conflict of Interest

The authors declare no conflict of interest.

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