Article

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Analysis of Risk Factors Associated with Organic Erectile Dysfunction in Patients with Type 2 Diabetes Mellitus and Erectile Dysfunction

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Background: Diabetes mellitus is a common metabolic disorder, and diabetic erectile dysfunction (DMED) is one of its common complications. The differentiation of the types of erectile dysfunction (ED) is fundamental to treatment, yet there is a lack of simple and efficacious tools for this purpose in clinical practice. In this study, we endeavor to predict ED types using commonly available clinical data from diabetic patients, aiming to develop and assess a risk prediction model for organic erectile dysfunction in individuals with type 2 diabetes.

Methods: The study was a retrospective analysis. Data were obtained from the hospital's internal medical record system. We selected and analyzed the clinical data of 250 patients with type 2 diabetes. Lasso regression was used for risk factor selection, and the selected variables were included in a multivariate logistic regression analysis to establish the risk prediction model. Internal validation was performed using the bootstrap method, and the discrimination, calibration, and clinical effectiveness of the model were evaluated using the C-index, calibration curve, decision curve analysis (DCA), and receiver operating characteristic (ROC) curve.

Results: Among the 250 patients, 168 (67.2%) were diagnosed with organic ED. The risk factors included in the logistic regression analysis were the duration of diabetes, low-density lipoprotein cholesterol (LDL-C), red blood cell distribution width (RDW), intima-media thickness of the carotid artery, diabetic retinopathy, diabetic nephropathy, and peripheral neuropathy. The C-index was 0.827 (95% confidence interval (CI) = 0.772–0.882). The distribution curve of the predicted values and the calibration curve of the model were well fitted. The decision curve analysis (DCA) suggested that using the model could be clinically beneficial when the threshold probability was between 28% and 100%.

Conclusion: By combining the duration of diabetes, carotid artery intima-media thickness, diabetic retinopathy, diabetic nephropathy, peripheral neuropathy, RDW, and LDL-C, this study preliminarily establishes a risk prediction model for organic ED in patients with type 2 diabetes mellitus. The model demonstrates good predictive performance.

Keywords: type 2 diabetes; risk factors; erectile dysfunction; nomograph

Introduction

Diabetes mellitus is a common metabolic disorder, and diabetic erectile dysfunction (DMED) is one of its prevalent complications. Multiple studies have shown that the prevalence of ED in diabetic patients is significantly higher than in healthy populations, with an overall incidence ranging from 52.5% to 75.1% [1–6]. DMED has become a significant public health issue. It is thought to have a multifactorial etiology, including neurological and psychological components [7]. The differentiation of ED types forms the foundation for personalized treatment. Clinicians often prescribe different treatment plans based on the distinct ED types presented by patients, making the accurate identification of ED types crucial. Various guidelines recommend using RigiScan for Nocturnal Penile Tumescence Rigidity (NPTR) testing to differentiate between psychogenic and organic ED. However, the high cost of this device limits its application in clinical practice. Currently, there is no clinical prediction tool available for diabetic patients to forecast the onset of organic erectile dysfunction (ED), posing a significant obstacle to the diagnosis and treatment of ED in diabetic patients.

In summary, there is an urgent need in clinical settings for a simple and effective tool to predict and assess the likelihood of organic ED in diabetic patients. Therefore, this study aims to collect demographic characteristics,

laboratory parameters, and relevant complications data of type 2 diabetic patients. By integrating International Index of Erectile Function 5 (IIEF-5) scores and NPTR testing, the study intends to investigate the distribution of organic and psychogenic ED in the type 2 diabetes population and explore the risk factors for organic ED in these patients [8]. Ultimately, this research aims to assist clinicians in assessing the sexual function of patients and promote the prevention and management of diabetic erectile dysfunction.

Materials and Methods

Study Subjects

A total of 250 male patients diagnosed with type 2 diabetes were recruited from January 2020 to January 2024 at the Second People's Hospital of Hefei City. The diagnosis of diabetes adhered to the diagnostic criteria outlined in the 2020 edition of the "Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2020" [9]. The IIEF-5 questionnaire was utilized for the initial diagnosis and assessment of erectile function [8]. All patients underwent two nights of NPTR monitoring, and experienced urologists specialized in male health diagnosed the type of erectile dysfunction according to the 2021 European Association of Urology guidelines for the treatment of sexual dysfunction [8].

Exclusion criteria for this study included recent cardiovascular or cerebrovascular events, neurological disorders, psychiatric disorders or use of antipsychotic medications, hematological disorders, urinary tract infections, cancer, pelvic surgery, spinal cord injury, penile fibrosis, obstructive sleep apnea syndrome (OSA), and the use of erectogenic drugs (such as tadalafil or sildenafil) or any medications known to have a negative impact on erectile function (such as beta-blockers or antidepressants).

This research was approved by the Clinical Experimental Ethics Committee of the Second People's Hospital of Hefei. Participants signed written informed consent before participation in the study, in accordance with the Helsinki Declaration.

Research Methods

Information was retrieved from the case management system with the data collection period spanning from January 2020 to January 2024. The collected data included the duration of diabetes, family history of diabetes, history of hypertension, smoking history, alcohol consumption history, age at admission, weight, body mass index (BMI), red cell distribution width (RDW), lipid profile (total cholesterol, triglycerides, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol), C-reactive protein, blood glucose-related parameters such as glycated hemoglobin (GHbA1) and fasting blood glucose.

Furthermore, carotid artery ultrasound assessment was conducted to evaluate carotid intima-media thickness (c-TMI) and the presence of plaques, with c-TMI and plaque defined in accordance with the Mannheim Consensus [10]. Screening results for diabetes complications, including fundus examination for diabetic retinopathy (DR), peripheral nerve conduction velocity examination for diabetic peripheral neuropathy (DNP), and assessment for diabetic kidney disease (DKD), were also recorded, with diagnosis made in accordance with established guidelines [9].

All data were collected by seasoned clinicians with extensive experience, ensuring the reliability and accuracy of the information obtained.

Statistical Processing

Preprocessing was conducted on all data obtained from the included patients. Descriptive statistics, including counts and percentages, were utilized to describe demographic characteristics, clinical laboratory and examination results, as well as accompanying comorbidities and complications. A chi-square analysis was performed to examine the differences between organic ED and psychogenic ED across groups.

Statistical analysis was carried out using R software (Version 4.3.2; available at https://www.r-project.org/; R Foundation; Vienna, Austria). Lasso regression was employed to screen for potential risk factors. The sample size adequacy for binary logistic regression analysis was assessed based on the Events per Variable (EPV) method, which recommends increasing the sample size by 10 for each additional independent variable. After meeting the criteria, variables selected by Lasso regression analysis were included in multivariable logistic regression analysis, and nomograms were generated.

Bootstrap resampling (n = 1000) was utilized for internal validation of the model. The discrimination, calibration, and clinical effectiveness of the model were evaluated using the C-index, calibration curve, and decision curve analysis (DCA). Regression coefficients (β), odds ratios (ORs) with 95% confidence intervals, and p-values were recorded for the included variables, with a two-tailed p-value less than 0.05 indicating statistical significance.

Result

Patient's General Condition

A total of 250 male patients with DMED were included in the study. Through evaluation using the IIEF-5 scale and NPTR monitoring, 82 patients (32.8%) were diagnosed with psychogenic DMED, while 168 patients were diagnosed with organic DMED. The collected patient information, including demographic characteristics, clinical laboratory tests, and examination data, was preprocessed into groups using methods such as clinical significance analysis, ROC curve analysis, or quartile methods. We have discov-

Table 1. Patient's general condition.

	Organic ED (N = 168), n (%)	Psychogenic ED (N = 82), n (%)	TRUE (N = 250), n (%)	*p*	χ^2
Age (y)				0.003	8.820
<50	90 (53.6%)	60 (73.2%)	150 (60.0%)		
≥50	78 (46.4%)	22 (26.8%)	100 (40.0%)		
Duration of DM (y)				<0.001	18.512
≤1	22 (13.1%)	20 (24.4%)	42 (16.8%)		
1–5	30 (17.9%)	27 (32.9%)	57 (22.8%)		
6–10	60 (35.7%)	24 (29.3%)	84 (33.6%)		
>10	56 (33.3%)	11 (13.4%)	67 (26.8%)		
Family history of DM				0.211	1.568
Yes	37 (22.0%)	24 (29.3%)	61 (24.4%)		
No	131 (78.0%)	58 (70.7%)	189 (75.6%)		
Hypertension				0.163	1.949
Yes	51 (30.4%)	18 (22.0%)	69 (27.6%)		
No	117 (69.6%)	64 (78.0%)	181 (72.4%)		
Smoking				0.229	1.447
Yes	77 (45.8%)	31 (37.8%)	108 (43.2%)		
No	91 (54.2%)	51 (62.2%)	142 (56.8%)		
Drinking				0.287	1.132
Yes	70 (41.7%)	40 (48.8%)	110 (44.0%)		
No	98 (58.3%)	42 (51.2%)	140 (56.0%)		
BMI (kg/m^2)				0.192	3.296
≤23.9	65 (38.7%)	26 (31.7%)	91 (36.4%)		
24–27.9	74 (44.0%)	34 (41.5%)	108 (43.2%)		
≥28	29 (17.3%)	22 (26.8%)	51 (20.4%)		
TG (mmol/L)				0.230	2.940
<1.7	62 (36.9%)	39 (47.6%)	101 (40.4%)		
1.7–2.3	46 (27.4%)	21 (25.6%)	67 (26.8%)		
≥2.3	60 (35.7%)	22 (26.8%)	82 (32.8%)		
TC (mmol/L)				0.182	3.410
<5.2	88 (52.4%)	52 (63.4%)	140 (56.0%)		
5.2–6.2	46 (27.4%)	20 (24.4%)	66 (26.4%)		
≥6.2	34 (20.2%)	10 (12.2%)	44 (17.6%)		
LDL-C (mmol/L)				0.042	6.327
<3.4	68 (40.5%)	41 (50.0%)	109 (43.6%)		
3.4–4.1	46 (27.4%)	27 (32.9%)	73 (29.2%)		
≥4.1	54 (32.1%)	14 (17.1%)	68 (27.2%)		
HDL-C (mmol/L)				0.096	2.767
<1	120 (71.4%)	50 (61.0%)	170 (68.0%)		
≥1	48 (28.6%)	32 (39.0%)	80 (32.0%)		
FPG (mmol/L)				0.306	1.049
≤6.1	41 (24.4%)	25 (30.5%)	66 (26.4%)		
>6.1	127 (75.6%)	57 (69.5%)	184 (73.6%)		
HbA1c (%)				0.263	1.252
<6.5	42 (25.0%)	26 (31.7%)	68 (27.2%)		
≥6.5	126 (75.0%)	56 (68.3%)	182 (72.8%)		
CRP (mg/L)				0.002	9.567
≤3.595	82 (48.8%)	57 (69.5%)	133 (53.2%)		
>3.595	86 (51.2%)	25 (30.5%)	117 (46.8%)		
RDW (%)				0.007	7.286
≤14.8	76 (45.2%)	52 (63.4%)	123 (49.2%)		
>14.8	92 (54.8%)	30 (36.6%)	127 (50.8%)		

Table 1. Continued.

	Organic ED (N = 168), n (%)	Psychogenic ED (N = 82), n (%)	TRUE (N = 250), n (%)	*p*	χ^2
Fbg (g/L)				0.030	4.694
≤2.715	88 (52.4%)	31 (37.8%)	119 (47.6%)		
>2.715	80 (47.6%)	51 (62.2%)	131 (52.4%)		
c-IMT				0.023	7.588
Normal	43 (25.6%)	30 (36.6%)	73 (29.2%)		
Increase	50 (29.8%)	30 (36.6%)	80 (32.0%)		
Plaque	75 (44.6%)	22 (26.8%)	97 (38.8%)		
DKD				<0.001	12.236
Yes	101 (60.1%)	30 (36.6%)	131 (52.4%)		
No	67 (39.9%)	52 (63.4%)	119 (47.6%)		
DR				<0.001	17.949
Yes	84 (50.0%)	18 (22.0%)	102 (40.8%)		
No	84 (50.0%)	64 (78.0%)	148 (59.2%)		
DPN				0.010	6.668
Yes	62 (36.9%)	17 (20.7%)	79 (31.6%)		
No	106 (63.1%)	65 (79.3%)	171 (68.4%)		

Abbreviations: DM, Diabetes Mellitus; BMI, body mass index; TG, triglyceride; TC, Total Cholesterol; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; FPG, Fasting Blood Glucose; HbA1c, Glycosylated Hemoglobin; CRP, C-Reactive Protein; RDW, red cell distribution width; Fbg, Plasma Fibrinogen; c-IMT, Carotid Intima-Media Thickness; DKD, diabetic kidney disease; DR, diabetic retinopathy; DPN, diabetic peripheral neuropathy; ED, erectile dysfunction.

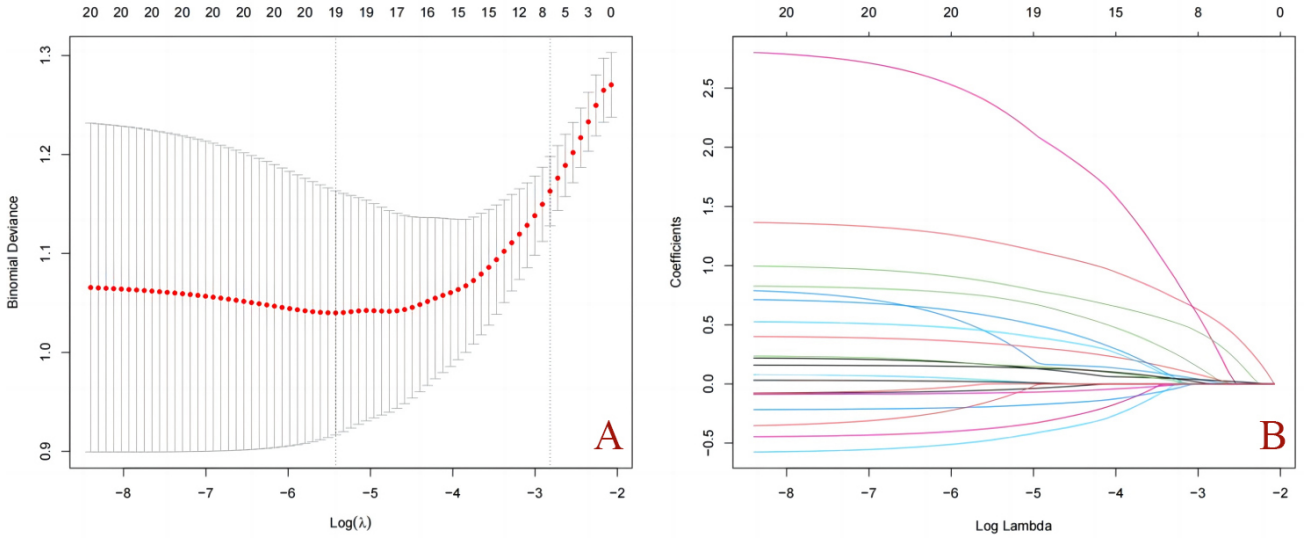

Fig. 1. The Lasso regression model achieved variable selection for demographic and clinical characteristics. (A) The selection of the optimal penalty coefficient λ in the Lasso model was conducted through 10-fold cross-validation and minimizing criteria. The dotted vertical lines are plotted at the optimal values following the minimum criteria (on the right) and the "one standard error" criteria (on the left). (B) The penalty plot illustrates the coefficients for the 22 variables, showcasing their respective penalization within the Lasso regression model.

ered that patients with organic Diabetes-Induced Erectile Dysfunction (DIED) often have a prolonged history of diabetes and also exhibit a higher incidence of diabetic complications and lipid metabolism disorders compared to those with psychogenic DIED. Detailed results are presented in Table 1.

Risk Factor Screening

Based on the cohort of 250 patients with DMED included in the study, variable selection was performed using the Lasso regression model. The optimal penalty coefficient was calculated within a standard error (SE) of the minimum penalty coefficient in the model through cross-

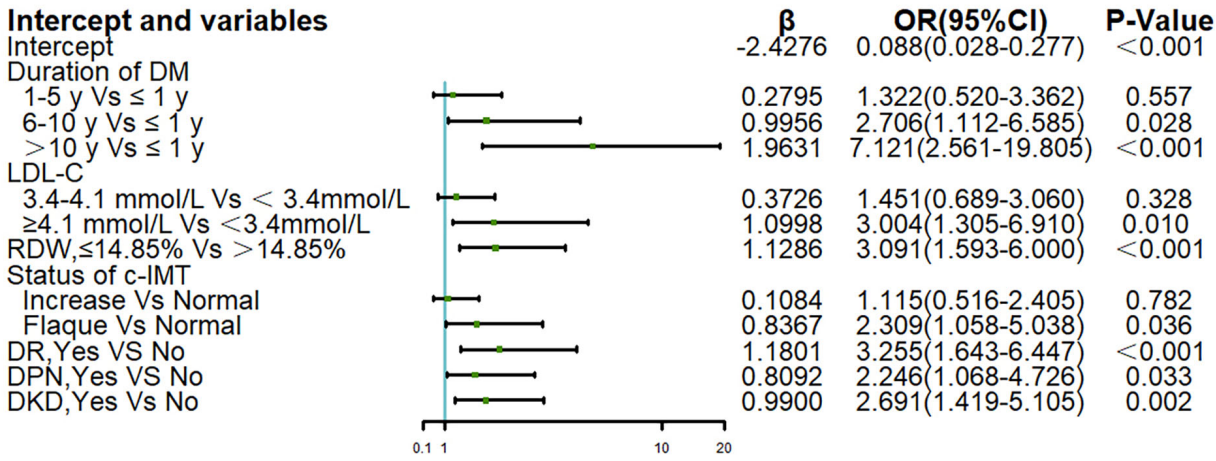

Fig. 2. Predictive factors for organic ED in type 2 diabetes patients. OR, odds ratio.

validation. The best penalty coefficient calculated was 0.0598 (Fig. 1). The variables planned to be included in the logistic regression model are as follows: duration of diabetes, low-density lipoprotein cholesterol, red cell distribution width, status of carotid intima-media thickness, concomitant diabetic retinopathy, concomitant diabetic kidney disease, and concomitant diabetic peripheral neuropathy.

Establishing the Logistic Regression Model

According to the EPV method, the sample size requirement for multiple logistic regression analysis was estimated. The sample size in this study essentially meets the requirements of the EPV method. Therefore, a logistic regression equation was established using seven potential risk factors, including diabetes duration, low-density lipoprotein cholesterol, red cell distribution width, intima-media thickness status of the carotid artery, concurrent DR, concurrent DKD, and concurrent DPN (Fig. 2). The nomogram vividly illustrates the variables included in the regression equation, along with the associated regression coefficients and OR. Based on this regression equation, a nomogram of the risk factor model for predicting organic ED in type 2 diabetes patients was constructed (Fig. 3). The nomogram clearly indicates that the duration of diabetes has the most significant impact on the onset of organic erectile dysfunction.

Evaluation of Discrimination and Calibration in the Line Chart

The Area Under the Curve (AUC) of the risk factor analysis model in this study is 0.827 (95% confidence interval (CI) = 0.772–0.882, $p < 0.001$), as shown in Fig. 4A. After 1000 iterations of bootstrap resampling for internal validation, the C-index corrected for overfitting bias is calculated to be 0.810. This indicates that the predictive model has good discriminative ability.

In the calibration curve, the distribution curve of the apparent predicted values of the logistic regression model in this study closely overlaps with the distribution curve obtained after resampling and correcting for overfitting bias, and aligns well with the curve representing the actual occurrence, as depicted in Fig. 4B. This indicates good calibration of the model.

Clinical Utility Assessment of the Nomogram

Clinical effectiveness was evaluated using decision curve analysis (DCA). The horizontal axis of the curve represents the threshold, which is the critical value by the model to determine whether a disease is present. The vertical axis of the curve is the net benefit rate after intervention applied to the patient. The decision curve plot for the model constructed in this study (Fig. 5) demonstrates that using the model to predict the likelihood of type 2 diabetes patients developing organic DMED would be clinically beneficial when the threshold probability (Pt) is between >28% and <100%. The decision curve plot shows a substantial separation from the two extreme curve lines, indicating the model's favorable clinical utility.

Discussion

As a prevalent complication of diabetes, DMED has emerged as a significant health concern. However, due to various limitations, clinicians often face challenges in comprehensively assessing the erectile status of DMED patients, thereby impacting subsequent treatment strategies. Currently, research on DMED has made progress both domestically and internationally, elucidating its primary mechanisms, including hemodynamic/vascular wall damage, endothelial dysfunction, neuropathy, endocrine disorders, cavernous smooth muscle injury, and tunica fibrosis.

In light of these complexities, we aimed to indirectly evaluate the erectile function of diabetic patients using readily available clinical data. In this study, we conducted

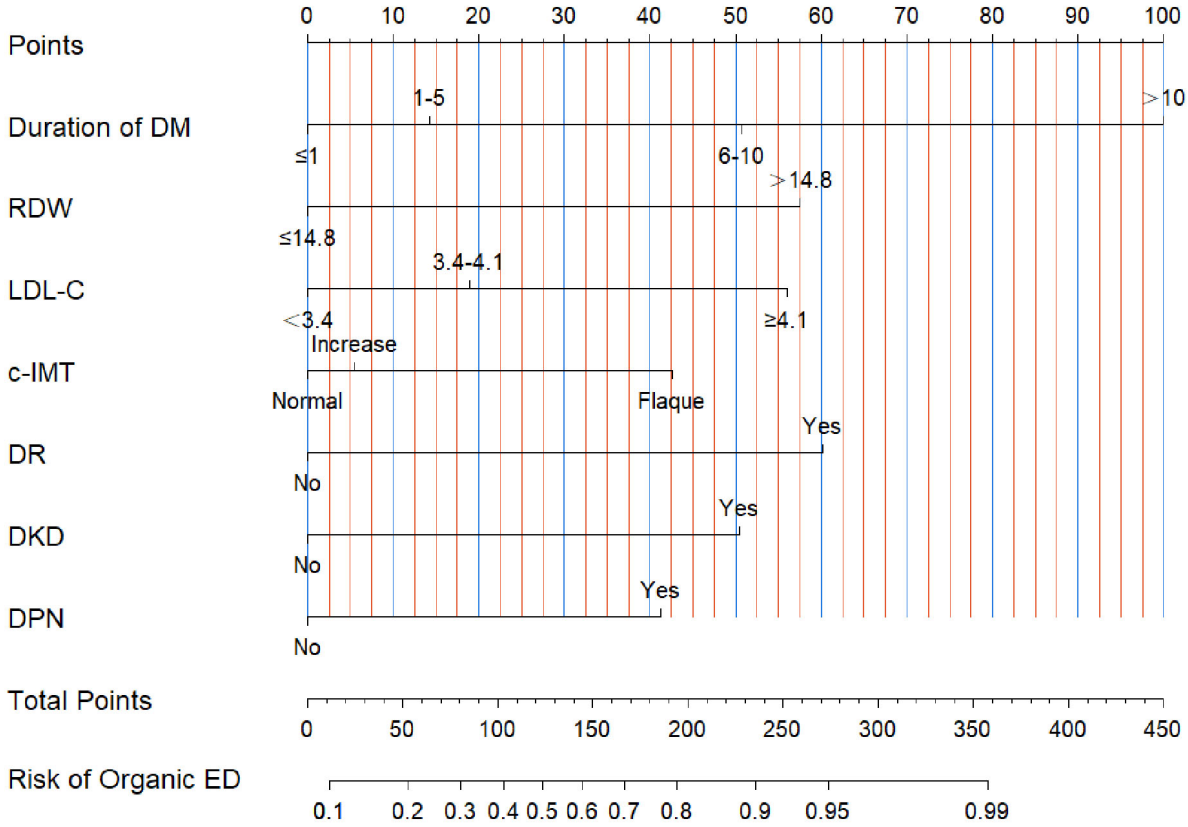

Fig. 3. Nomogram of organic diabetic erectile dysfunction (DMED) in type 2 diabetes patients.

a preliminary exploration of the risk factors for organic ED in patients with type 2 diabetes through multifactorial logistic regression analysis. We developed a nomogram based on parameters such as diabetes duration, low-density lipoprotein cholesterol, red cell distribution width, carotid artery intima-media thickness, and the presence of diabetic retinopathy, nephropathy, and neuropathy.

Furthermore, internal validation demonstrated promising discrimination, calibration, and clinical utility of the model. Our research offers clinicians a simple and reliable tool for classifying DIED, thereby facilitating the clinical assessment of patients' sexual function. This aids in the selection of treatment plans for patients, thereby enhancing the awareness of clinicians for early prevention and increasing their attention to the overall health of patients.

In previous clinical and scientific endeavors, the distinct nature of DIED was often overlooked. Some clinicians even generalized all cases of DIED as organic erectile dysfunction, a practice that is not conducive to accurate diagnosis and treatment. Our research has found that there is still a proportion of patients with DIED who have psychological erectile dysfunction, accounting for 32.8%. This could be due to mental and psychological factors such as depression. Indeed, studies have highlighted a notable prevalence of depression among individuals with diabetes, with diabetics being almost twice as likely to experience depression compared to non-diabetics. These findings corroborate our hypothesis [11,12]. Therefore, the role of psychological factors in diabetic-induced erectile dysfunction warrants close attention and underscores the importance of comprehensive assessment and management strategies in clinical practice.

The duration of diabetes is closely correlated with the onset of organic DMED. Studies have shown that as the duration of diabetes increases, the incidence of ED gradually rises, showing an accelerating trend [13,14]. Patients who are in a prolonged state of hyperglycemia experience continuous damage to vascular walls, endothelial cells, and tunica structures, increasing the risk of organic ED.

In our study, employing multifactorial logistic regression analysis, we observed that compared to diabetes duration $\leq$1 year, a duration $\geq$6 years and $\leq$10 years (OR = 2.706, 95% CI = 1.112–6.585), and a duration $>$10 years (OR = 7.121, 95% CI = 2.561–19.805) were independent risk factors for diabetes complicated by ED. This finding underscores the significance of early intervention in averting the development of organic DMED.

Low-density lipoprotein cholesterol (LDL-C) plays a pivotal role in the development of organic ED. Oxidized LDL-C is highly immunogenic and can trigger thrombus formation and endothelial inflammation, leading to hemo-

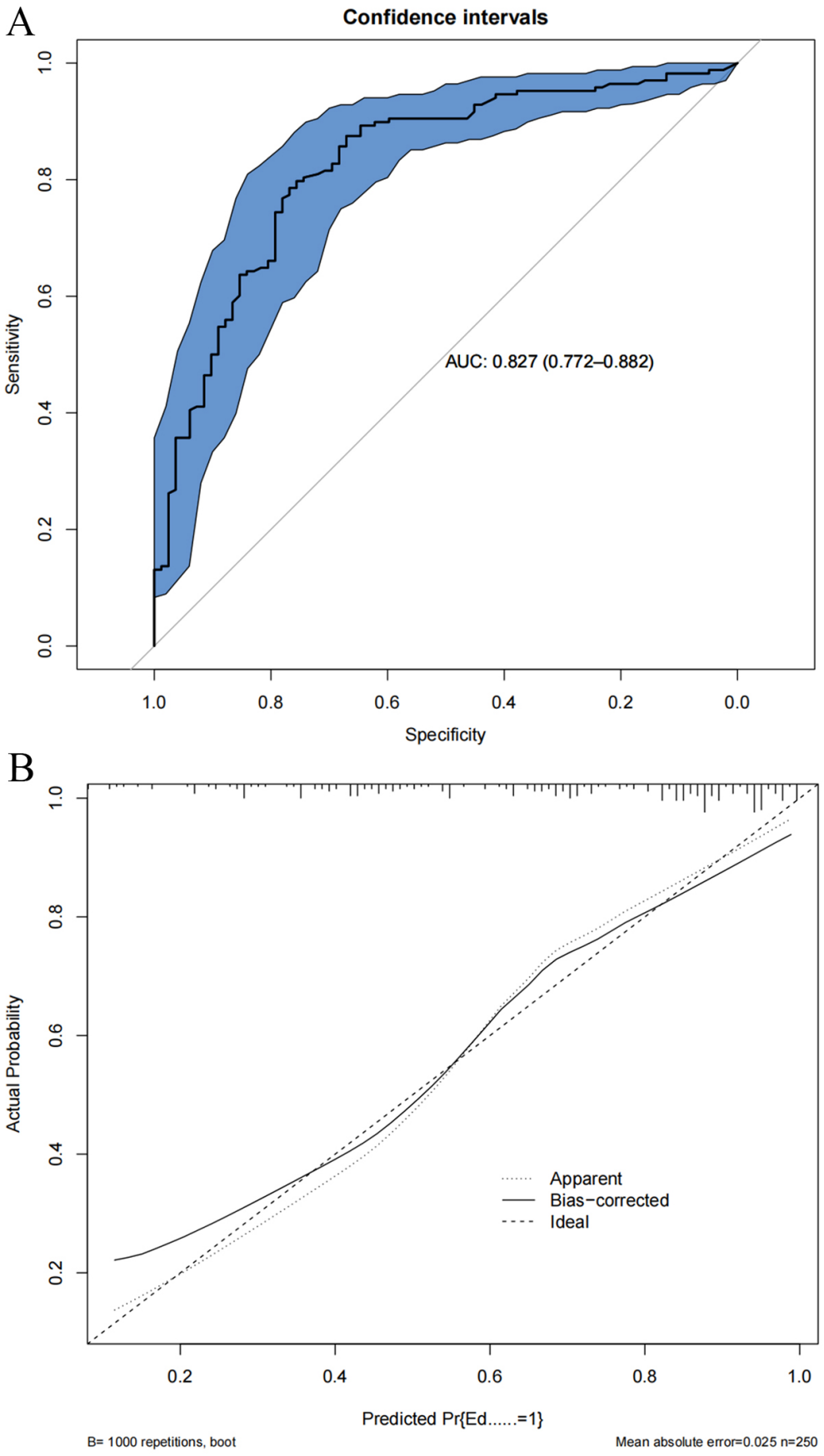

Fig. 4. ROC curve and calibration curve for patients with diabetic erectile dysfunction (DMED). (A) ROC Curve. (B) Calibration curve. ROC, receiver operating characteristic; AUC, Area Under the Curve.

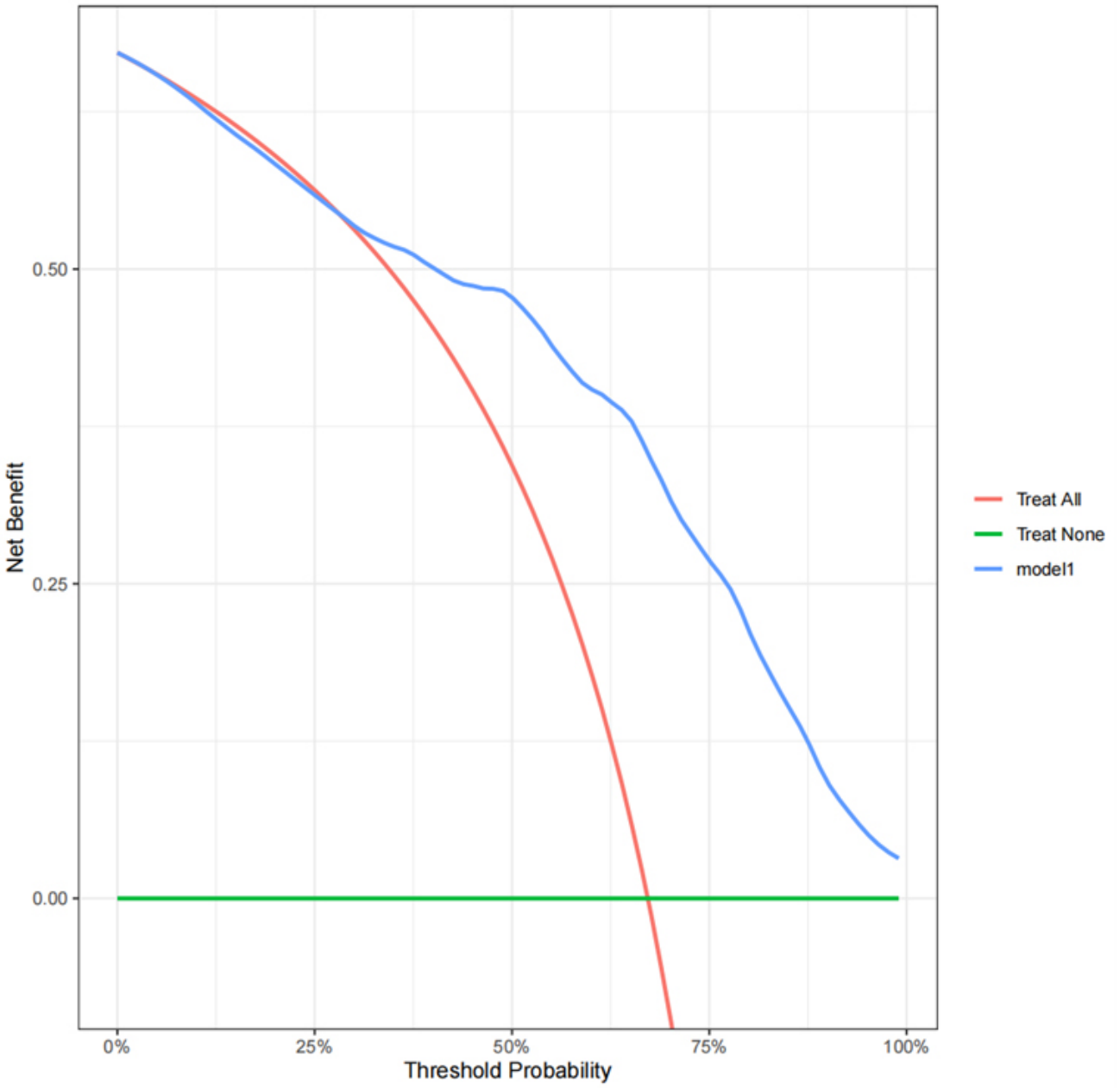

Fig. 5. The clinical decision curve for predicting organic DMED in DMED patients.

dynamic/vascular wall damage and endothelial dysfunction, ultimately resulting in ED. Previous studies have established a correlation between LDL-C levels and the risk of ED [15,16]. Moreover, one study has suggested a potential therapeutic effect of statin drugs on ED [17]. In our study, we identified a correlation between high LDL-C levels and the occurrence of organic ED in diabetic patients, with an OR of 3.004 and a 95% CI of 1.305–6.910.

RDW has been considered to be associated with cardiovascular events, cancer, and kidney disease [18,19]. Some studies suggest that RDW also has predictive value for ED [20,21]. RDW is closely linked to inflammatory mediators such as tumor necrosis factor, and elevated RDW levels often signify increased levels of low-grade inflammation and heightened oxidative stress, which are common mechanisms underlying organic ED [22]. In our study, we observed an association between RDW (OR = 3.091, 95% CI = 1.593–6.000) and the occurrence of organic DMED in patients with type 2 diabetes.

Carotid intima-media thickness reflects vascular wall damage to some extent. Multiple studies have confirmed that the carotid intima-media thickness and plaque occurrence rate in patients with erectile dysfunction (ED) are significantly higher than in non-ED patients [23,24]. In diabetic individuals, abnormal glucose metabolism, increased blood viscosity, dysregulation of vascular contractility and relaxation factors, along with the covalent binding of advanced glycation end-products (AGEs) to vascular colla-

gen due to hyperglycemia, contribute to increased vascular thickness, reduced vascular elasticity, vascular stenosis, and the formation of plaque or thrombus. These mechanisms severely impede penile blood circulation, resulting in decreased blood perfusion to the corpora cavernosa, thereby promoting the occurrence of organic ED [25–27]. This study found that compared to a normal carotid intima-media layer, the formation of carotid plaque is an independent risk factor for ED in patients with diabetes (OR = 2.309, 95% CI = 1.058–5.038).

DR, DKD, and diabetic peripheral neuropathy (DPN) are prevalent complications of diabetes that are closely linked to the occurrence of ED in diabetic patients. Numerous studies have highlighted an association between microvascular complications of diabetes, such as retinopathy, nephropathy, and peripheral neuropathy, and the development of ED [28–30]. The pathogenesis of organic ED shares similarities with that of diabetic complications. In addition to hemodynamic/vascular wall damage and endothelial dysfunction, neuropathy serves as a common contributing factor to these complications. Abnormal glucose metabolism can induce neuropathy through various pathways, leading to reduced synthesis of neurogenic nitric oxide (NO) and causing degeneration of the sacral (S2—S4) sensory nerves, resulting in decreased sexual stimulation impulses [31–35].

In our study, we also observed associations between DR (OR = 3.255, 95% CI = 1.643–6.447), DKD (OR = 2.691, 95% CI = 1.419–5.105), and DPN (OR = 2.246, 95% CI = 1.068–4.726) with the occurrence of erectile dysfunction in diabetic males.

In this study, variable selection was carried out using the Lasso regression method. Lasso regression is particularly suitable for high-dimensional data (where the number of variables greatly exceeds the sample size), dealing with collinearity, and handling small sample clinical data. Therefore, in this study, Lasso regression was utilized for variable selection. According to the Transparent Reporting of a multivariable prediction model for Individual Prognosis or Diagnosis (TRIPOD) statement, the model constructed by the multiple logistic regression analysis method in this study was evaluated and validated. Due to the small sample size and single-center nature of the study, internal validation was performed using the Bootstrap method. Model evaluation included assessment of discrimination, calibration, and clinical utility. The C-index of the risk factor analysis model in this study was 0.827 (95% CI = 0.772–0.882), indicating good discrimination of the model. Calibration analysis revealed high concordance between the distribution of the model's apparent predicted values and the distribution curve obtained after adjusting for overfitting through resampling, demonstrating good fit with the ideal curve (standard curve) and thus affirming the model's calibration.

Additionally, DCA was introduced to assess clinical utility. The DCA curve indicated that the decision curve of the model was far from the two extreme situation curves, indicating good clinical utility of the model.

This study inevitably possesses certain limitations. Firstly, the sample size remains insufficient, potentially leading to instability in the multiple logistic regression model. Additionally, due to the relatively small sample size, only internal validation of the model was conducted, limiting its generalizability. Future research should focus on external validation and optimization of the model using larger and multi-center datasets. Furthermore, testosterone levels, time within target range for glucose, and other indicators are crucial factors in assessing diabetic ED. Diabetes adversely affects gonadal function, and reduced androgen levels and receptor sensitivity can inhibit penile nitric oxide synthase, thereby impacting the neural control of muscles essential for erection and potentially inducing ED. However, the prevalence of missing data within clinical databases hindered the inclusion of these factors in our model, inevitably affecting the reliability of our results.

Despite these limitations, our study represents a preliminary exploration of the risk factors for organic DMED in patients with type 2 diabetes. We constructed a model based on parameters such as diabetes duration, LDL-C, red cell distribution width, carotid artery intima-media thickness, and comorbidities like diabetic retinopathy, nephropathy, and neuropathy. Furthermore, internal validation suggests that the model exhibits good discrimination, calibration, and clinical utility. This serves as a foundation for future external validation and optimization of the model using larger and multi-center datasets.

In our study, we found that ED is moderately associated with diabetic complications, metabolic disorders, and the duration of the condition among patients. However, we acknowledge that we have not fully elucidated the causal relationships involved. In clinical practice, ED is often regarded as a potential indicator of certain cardiovascular diseases. Whether this characteristic can be leveraged to predict diabetic complications is a question that may be the focus of our future research.

Additionally, in this study, we selected clinical data of patients as predictive factors. However, due to various constraints, common influencing factors such as testosterone and vitamin D levels were not included. Future research will necessitate a more comprehensive analysis that incorporates these elements.

Conclusion

Our study demonstrates that diagnosing diabetic complications in clinical practice can assist in assessing erectile function in male diabetic patients and provide an early warning for the onset of organic erectile dysfunction. By distinguishing the types of erectile dysfunction, clinicians

are able to formulate more individualized treatment plans for patients, particularly for those who exhibit suboptimal responses to pharmacotherapy. This is especially valuable in primary healthcare settings, where these insights may have broader practical application.

Availability of Data and Materials

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

Author Contributions

Conceptualization: DN, WW and YZ; methodology, software, validation, formal analysis, investigation: ML; resources: DN, WW, and CX; data curation: ML and CX; writing - original draft: ML and YZ; writing - review & editing: DN, WW and YZ; visualization: ML; supervision: DN, WW and YZ; project administration: YZ; funding acquisition: YZ. All authors contributed significantly to editorial changes of important 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

This research was approved by the Clinical Experimental Ethics Committee of the Second People's Hospital of Hefei. Participants signed written informed consent before participation in the study, in accordance with the Helsinki Declaration.

Acknowledgment

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Conflict of Interest

The authors declare no conflict of interest.

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