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Vitamin D deficiency and the risk of diabetic retinopathy in patients with type 2 diabetes in Tibet: a cross-sectional analysis

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Abstract

Background Diabetic retinopathy (DR) is one of the most common complications of diabetes worldwide. The aim of this study was to assess the prevalence of DR in hospitalized patients with type 2 diabetes (T2DM) in Tibet and to identify risk factors that may influence the occurrence of DR.

Methods This was a cross-sectional study conducted in a third-class hospital in the Tibet Autonomous Region. The prevalence of DR in hospitalized patients with T2DM was measured. Univariate and multivariate logistic regression, restricted cubic spline (RCS) analysis and receiver-operating characteristic curve analysis were used to investigate the risk factors for DR.

Results The prevalence of DR was 29.3%. The duration of diabetes; concentrations of 25-OH-VitD3, hemoglobin, fasting insulin, alanine aminotransferase, total bilirubin, and creatinine; and HOMA-IR were significantly different between DR patients and non-DR patients (all $P < 0.05$). Univariate and multivariate logistic regression revealed that a longer duration of diabetes and lower 25-OH-VitD3 levels were associated with increased DR risk. RCS analysis suggested overall positive associations of the duration of diabetes and 25-OH-VitD3 concentrations with DR risk (P nonlinearity < 0.05). The turning points for the duration of diabetes and 25-OH-VitD3 concentrations were 5.1 years and 10.6 ng/mL, respectively. The sensitivity, specificity, and area under the receiver-operating characteristic curve for the combination of the duration of diabetes and 25-OH-VitD3 levels were 79.4%, 69.4% and 0.764, respectively.

Conclusions Given the high prevalence of DR in hospitalized patients with T2DM in Tibet, vitamin D supplementation seems to be important in the prevention of DR to some degree.

Keywords Diabetic retinopathy, Vitamin D, 25-OH-VitD3, Tibet, Plateau

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Introduction

The prevalence and incidence of diabetes have increased worldwide in recent years. According to the 10th edition of the IDF Diabetes Atlas, 537 million adults aged 20–79 years had diabetes in 2021, and this number is estimated to increase to 643 million by 2030 and 783 million by 2045 [1]. Diabetes and its complications cause great health and economic burdens and have become major public health issues in China [2]. Diabetic retinopathy (DR) is one of the most common complications of diabetes and is the leading cause of blindness in people of working age worldwide [3].

The prevalence of DR varies among countries and regions, possibly because of racial differences, economic conditions, health care systems, lifestyles, and other factors [4]. The plateau region presents a unique geographical environment characterized by hypoxia, low temperatures, and significant diurnal temperature variations. However, the prevalence of DR in the plateau region is still lacking.

A previous study reported many risk factors for DR, including poor glycemic control, smoking, a long duration of diabetes, and hypertension [5, 6]. However, other possible risk factors are not fully recognized. 25-OH-VitD3, a form of vitamin D, was found to be associated with the occurrence of DR in several studies [7, 8]. However, other studies yielded negative results for the association between 25-OH-VitD3 concentrations and the risk of developing DR [9, 10]. Importantly, whether 25-OH-VitD3 is a risk factor for the development of DR in the plateau region is still unknown.

In this study, we aimed to assess the prevalence of DR in hospitalized T2DM patients in Tibet, the highest plateau in the world, and to identify risk factors that may influence the occurrence of DR. Our study provides evidence for diabetes management and helps with the early recognition of DR.

Methods

Study design and participants

This cross-sectional study was conducted on patients with T2DM who were referred to the Department of Endocrinology and Metabolism, People's Hospital of Tibet Autonomous Region, from January 2023 to December 2023. A total of 365 individuals were included in this study (Fig. 1). The inclusion criteria for this study were the presence of T2DM and adult age (451 individuals). The exclusion criteria were as follows: (1) history of diabetic ketoacidosis or hyperosmolar syndrome within 3 months (21 individuals); (2) serious concomitant diseases, including diseases of the liver, kidneys, cardiovascular, nervous and endocrine systems, which affected the results of the study (17 individuals); (3) bone fracture or orthopedic surgeries during the past year (13 individuals); and (4) medications for glucocorticoids or vitamin D or any other medication that could affect vitamin D metabolism (35 individuals). A group sample size of 365 would achieve 89.4% power to detect a difference in 25-OH-VitD3 concentrations with a Mann–Whitney *U* test when the significance level (alpha) of the test is 0.05 in both groups. Oral informed consent was obtained from all the patients, and the study was conducted in compliance with the Helsinki declaration. The study protocol was approved by the Ethics Committee of Tibet Autonomous Region Peoples Hospital (No. ME-TBHP-24-KJ-041).

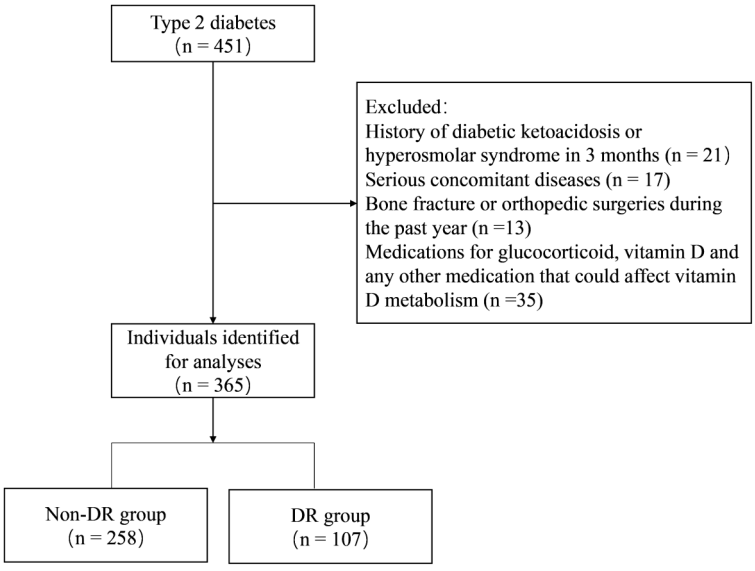

Fig. 1 Flow chat of the study

Demographic data and anthropometric measurements

The demographic data, including sex, age, duration of diabetes, smoking history and drinking history, were collected from the electronic medical records. Altitude was calculated by the region of residence. The weights of the patients were measured via a digital scale with a precision of 0.1 kg. Height was assessed via a meter with a precision of 0.1 m. Body mass index was calculated as weight (kg)/height (meter)^2.

Blood collection and measurement

Blood samples were drawn from each patient and collected after 10 ~ 12 h of fasting. Fasting blood glucose, alanine aminotransferase, aspartate aminotransferase, total bilirubin, creatinine, uric acid, calcium, triglyceride, total cholesterol and low-density lipoprotein cholesterol concentrations were detected *via* an automatic biochemical analyzer (Abbott Diagnostics, Abbott Park, IL, USA). Hemoglobin was measured with a Sysmex XE-2100 (Sysmex, Kobe, Japan). The 25-OH-VitD3 levels in the serum samples were measured via a chemiluminescent microparticle immunoassay on the Architect-I 2000 system (Abbott Diagnostics). Glycosylated hemoglobin A1c (HbA1c) was analyzed via a Tosoh Automated Glycohemoglobin Analyzer (Tosoh Corporation, Tokyo, Japan). Fasting insulin, parathyroid hormone and TSH levels were detected with an ADVIA Centaur XP immunoassay system (Siemens Diagnostics, Tarrytown, NY, USA).

Definition of diabetic retinopathy and atherosclerosis

The retinal structure was measured via optic-centered fundus images and optical coherence tomography. DR was diagnosed by an ophthalmologist on the basis of the presence of one or more of the following signs: microaneurysms, cotton-wool spots, intraretinal hemorrhages, and macular edema [11]. Diabetic retinopathy can be divided into two categories: nonproliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). NPDR is defined by alterations in the retinal vasculature, whereas PDR is characterized by neovascularization and is more severe than NPDR is [12]. In this study, the two categories were combined into a single group (DR group) for further statistical analysis. Atherosclerosis is defined as the presence of thickening or plaque on the wall of the carotid artery and/or lower-limb artery when evaluated by ultrasound [13].

Statistical analyses

The Shapiro–Wilk test was applied to test the normality of continuous variables. Data are presented as the means ± standard deviations or medians (interquartile ranges), as appropriate. For comparison of two groups, Student's *t* test and the Mann–Whitney *U* test were used for the normally distributed variables and nonnormally distributed variables, respectively. Categorical variables are reported as numbers (%), and Pearson's chi-square test was used to compare differences between groups. Univariate and multivariate logistic regression analyses were performed to evaluate the baseline parameters that predict DR in T2DM patients. Restricted cubic spline (RCS) were constructed to explore any nonlinear correlations of the duration of diabetes and 25-OH-VitD3 concentrations with the risk of developing DR. The diagnostic accuracy of the duration of diabetes and/or 25-OH-VitD3 concentrations was assessed with a receiver operating characteristic (ROC) curve and the area under the ROC curve. $P<0.05$ was considered statistically significant. All the statistical analyses were performed with SPSS (version 22.0) and R software (version 4.3.2).

Sensitivity analysis

We further conducted two sensitivity analyses for two potentially important factors. In sensitivity analysis 1, male sex was taken into consideration because it was suggested that among T2DM patients, females have a higher prevalence of DR than males do [14]. In analysis 2, smoking status was taken into consideration because in a review article, the risk of developing DR was shown to be significantly decreased in smokers with T2DM [15]. Sensitivity analysis was performed via multivariate logistic analysis.

Results

Demographic and clinical characteristics of the study population

A total of 365 hospitalized patients with T2DM were included, and their demographic and clinical characteristics are presented in Table 1. There were 275 (75.3%) male patients, and the average age was 55.9 years. The median duration of diabetes, altitude and 25-OH-vitD3 concentrations were 5 years, 3657 m and 10.7 ng/mL, respectively (Table 1). Notably, the average fasting blood glucose concentrations and HbA1c values were 10.2 mmol/L and 11.8%, respectively (Table 1).

Comparisons of patients with and without DR

To compare the demographic and clinical characteristics between patients with and without DR, patients were divided into non-DR (258 patients, 70.7%) and DR (107 patients, 29.3%) groups. Compared with those without DR, patients with DR had a longer duration of diabetes [10 (6.0, 16.0) years *vs.* 3 (0.7, 8.0) years, $P<0.001$], lower 25-OH-vitD3 [9.30 (6.50, 13.5) ng/mL *vs.* 11.3 (8.60, 14.6) ng/mL, $P=0.001$], lower hemoglobin (158.6 ± 24.9 g/L *vs.* 166.3 ± 20.6 g/L, $P=0.005$), higher fasting insulin [14.3 (6.28, 27.1) μIU/mL *vs.* 9.65 (5.45, 17.4) μIU/mL, $P=0.020$], lower alanine aminotransferase

Table 1 Demographic and clinical characteristics of T2DM patients with or without DR

Characteristics	Total (*n* = 365)	Non-DR (*n* = 258)	DR (*n* = 107)	t/z/x^2 value	*P* value
Male, n (%)	275 (75.3)	192 (74.4)	83 (77.6)	-0.404	0.525
Age, year	55.9 ± 11.3	55.6 ± 11.9	56.6 ± 9.84	-0.830	0.408
Age distribution, n (%)				0.005	1.000
< 65, year	284 (77.8)	201 (70.8)	81 (70.4)		
≥ 65, year	81 (22.2)	57 (29.2)	24 (29.6)		
Altitude, meters	3657 (3657, 4002)	3657 (3657, 4004)	3657 (3657, 3914)	0.834	0.404
Duration of diabetes, years	5.0 (1.0, 10.0)	3.0 (0.7, 8.0)	10.0 (6.0, 16.0)	-7.598	< 0.001
Smoking, n (%)	93 (25.5)	62 (24.1)	31 (29.2)	-1.033	0.310
Drinking, n (%)	76 (20.8)	51 (19.8)	25 (23.6)	-0.634	0.426
Height, centimeters	169.2 ± 7.26	169.2 ± 7.39	169.0 ± 6.97	-0.220	0.826
Weight, kg	73.7 ± 12.5	74.4 ± 12.9	72.2 ± 11.3	1.557	0.120
Body mass index, kg/m^2	25.8 ± 4.01	26.0 ± 4.20	25.2 ± 3.47	1.623	0.106
25-OH-VitD3, ng/mL	10.7 (7.80, 14.5)	11.3 (8.60, 14.6)	9.30 (6.50, 13.5)	3.349	0.001
Hemoglobin, g/L	164.1 ± 22.2	166.3 ± 20.6	158.6 ± 24.9	2.825	0.005
Fasting blood glucose, mmol/L	10.2 ± 5.71	10.1 ± 6.17	10.4 ± 4.42	-0.443	0.658
Fasting insulin, μIU/mL	10.5 (5.69, 19.0)	9.65 (5.45, 17.4)	14.3 (6.28, 27.1)	-2.323	0.020
TSH, mIU/L	2.36 (1.43, 3.94)	2.39 (1.44, 3.94)	2.34 (1.38, 3.94)	0.299	0.765
HbA1c, %	11.8 ± 2.39	11.9 ± 2.47	11.9 ± 2.19	0.339	0.735
Parathyroid hormone, pg/mL	79.7 (58.6, 86.6)	79.7 (61.4, 84.3)	79.7 (56.9, 94.9)	0.320	0.749
Alanine aminotransferase, U/L	30.0 (20.0, 40.0)	34.0 (21.0, 42.0)	26.0 (18.0, 37.4)	2.955	0.003
Aspartate aminotransferase, U/L	22.0 (17.0, 27.2)	22.0 (17.0, 27.2)	21.0 (15.0, 27.2)	1.714	0.086
Total bilirubin, μmol/L	14.7 (10.6, 17.4)	15.0 (11.1, 17.3)	12.9 (9.40, 18.0)	2.200	0.028
Creatinine, μmol/L	65.0 (55.0, 72.0)	65.0 (54.0, 69.3)	66.4 (56.0, 78.0)	-2.413	0.016
Uric acid, mmol/L	348.2 (295.5, 392.5)	348.2 (298.0, 384.3)	348.2 (291.0, 416.0)	1.128	0.259
Calcium, mmol/L	2.16 (2.10, 2.25)	2.16 (2.10, 2.24)	2.15 (2.08, 2.26)	0.135	0.893
Triglycerides, mmol/L	1.36 (1.04, 1.60)	1.34 (1.04, 1.57)	1.39 (1.02, 1.77)	-0.362	0.717
Total cholesterol, mmol/L	4.33 (3.73, 4.78)	4.33 (3.70, 4.73)	4.33 (3.82, 4.97)	1.500	0.134
LDL-C, mmol/L	2.57 (2.09, 2.93)	2.56 (2.07, 2.93)	2.57 (2.18, 2.97)	-0.267	0.789
Atherosclerosis, n (%)	224 (61.4)	153 (63.8)	71 (68.9)	-0.854	0.355
HOMA-β	34.0 (18.2, 73.5)	31.2 (17.7, 71.7)	38.6 (21.1, 77.7)	-1.035	0.301
HOMA-IR	4.51 (2.08, 8.81)	4.09 (2.02, 7.61)	5.71 (2.50, 11.4)	-2.387	0.017

Note Data are presented as the means ± SDs, numbers (%) or medians (interquartile ranges), as appropriate

Abbreviations TSH, thyroid stimulating hormone; HbA1c, glycosylated hemoglobin AIc; LDL-C, low-density lipoprotein cholesterol

[26.0 (18.0, 37.4) U/L *vs.* 34.0 (21.0, 42.0) U/L, $P=0.003$], and lower total bilirubin [12.9 (9.40, 18.0) U/L *vs.* 15.0 (11.0, 17.3) U/L, $P=0.028$], higher creatinine [66.4 (56.0, 78.0) μmol/L *vs.* 65.0 (54.0, 69.3) μmol/L, $P=0.016$], and higher HOMA-IR [5.71 (2.50, 11.4) *vs.* 4.09 (2.02, 7.61), $P=0.017$]. There were no differences in sex, age, altitude, smoking status, drinking status, height, weight or other biochemical parameters between the two groups (all $P>0.05$) (Table 1).

Independent risk factors associated with the development of DR in hospitalized T2DM patients

The results of the univariate logistic regression analysis of demographic and clinical characteristics in relation to DR are listed in Table 2. The results revealed that a longer duration of diabetes, lower 25-OH-VitD3 and hemoglobin concentrations, higher fasting insulin concentrations, lower alanine aminotransferase concentrations and higher creatinine concentrations were associated with a greater incidence of DR. Subsequently, stepwise multivariate logistic regression analysis was introduced among all the factors correlated with the risk of developing DR in the univariate logistic regression to identify the independent effects. As shown in Table 2; Fig. 2, the duration of diabetes (OR = 1.120; 95% CI 1.072, 1.170) and 25-OH-VitD3 concentrations (OR = 0.932; 95% CI 0.885, 0.982) were associated with the risk of developing DR. The sensitivity analyses presented in Supplementary Tables 1 and Supplementary Table 2 enhanced the reliability of the results.

Associations of duration of diabetes and 25-OH-VitD3 concentrations with the risk of developing DR

In addition, we investigated the nonlinear relationships of the duration of diabetes and 25-OH-VitD3 concentrations with the risk of developing DR. The RCS regression

Table 2 Logistic regression analysis of risk factors associated with the development of DR in T2DM patients

Characteristics	Univariable OR (95% CI)	*P* value	Multivariable OR (95% CI)	*P* value
Male	0.841 (0.493, 1.434)	0.525		
Age	1.008 (0.988, 1.028)	0.442		
Altitude	0.999 (0.999, 1.000)	0.096		
Duration of diabetes	1.135 (1.091, 1.181)	< 0.001	1.120 (1.072, 1.170)	< 0.001
Smoking	1.300 (0.783, 2.158)	0.310		
Drinking	1.247 (0.724, 2.146)	0.426		
Height	0.997 (0.966, 1.028)	0.825		
Weight	0.985 (0.967, 1.004)	0.121		
Body mass index	0.953 (0.900, 1.010)	0.106		
25-OH-VitD3	0.927 (0.882, 0.973)	0.002	0.932 (0.885, 0.982)	0.008
Hemoglobin	0.984 (0.973, 0.995)	0.003	0.991 (0.980, 1.002)	0.108
Fasting blood glucose	1.008 (0.971, 1.047)	0.661		
Fasting insulin	1.018 (1.002, 1.034)	0.027	1.006 (0.990, 1.022)	0.491
TSH	0.983 (0.943, 1.025)	0.426		
HbA1c	1.016 (0.925, 1.117)	0.734		
Parathyroid hormone	1.002 (0.997, 1.008)	0.418		
Alanine aminotransferase	0.989 (0.979, 0.999)	0.025	0.996 (0.987, 1.005)	0.410
Aspartate aminotransferase	0.995 (0.983, 1.006)	0.370		
Total bilirubin	0.974 (0.940, 1.009)	0.137		
Creatinine	1.017 (1.006, 1.028)	0.002	1.004 (0.992, 1.017)	0.495
Uric acid	1.002 (0.999, 1.004)	0.184		
Calcium	0.948 (0.346, 2.596)	0.917		
Triglycerides	1.064 (0.849, 1.335)	0.589		
Total cholesterol	1.239 (0.982, 1.563)	0.071		
LDL-C	1.091 (0.811, 1.442)	0.593		
Atherosclerosis	1.262 (0.770, 2.066)	0.356		
HOMA-β	1.001 (0.999, 1.002)	0.295		
HOMA-IR	1.029 (0.999, 1.059)	0.054		

Abbreviations TSH, thyroid stimulating hormone; HbA1c, glycosylated hemoglobin AIc; LDL-C, low-density lipoprotein cholesterol

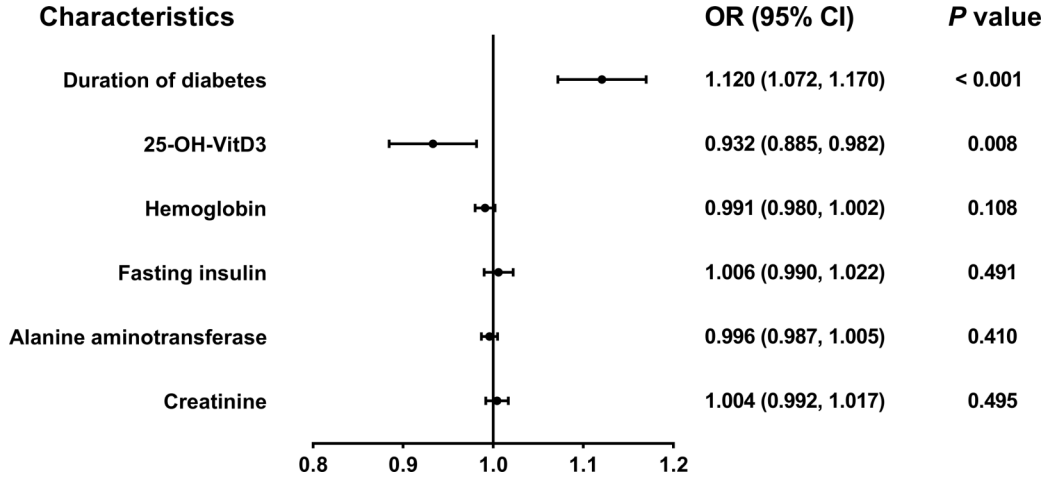

Fig. 2 Forest plot of the multivariate logistic regression baseline variables predicting the development of DR in patients with T2DM

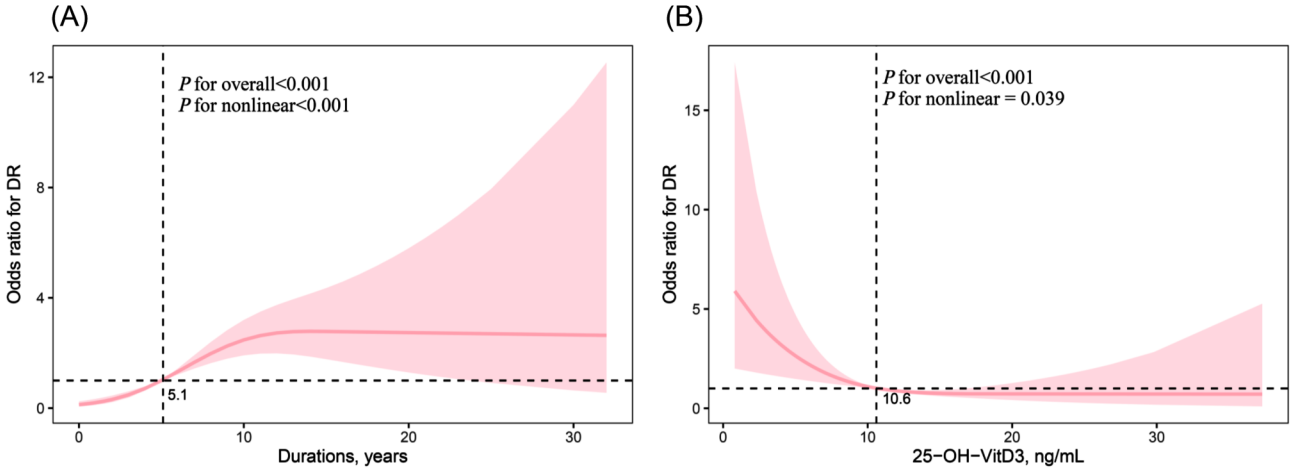

Fig. 3 The correlations of the duration of diabetes and 25-OH-VitD3 concentrations with the risk of developing DR evaluated by restricted cubic splines. DR, diabetic retinopathy

Table 3 AUC parameters of duration of diabetes and 25-OH-VitD3 for predicting the incidence of DR

Model Groups	AUC (95% CI)	*P* values	Sensitivity (%)	Specificity (%)
Model 1	0.752 (0.700-0.804)	< 0.001	84.1	57.8
Model 2	0.611 (0.545–0.678)	= 0.001	45.8	76.7
Model 3	0.764 (0.713–0.815)	< 0.001	79.4	69.4

Note Model 1 contains the duration of diabetes. Model 2 contains 25-OH-VitD3. Model 3 included both the duration of diabetes and 25-OH-VitD3

model revealed that the duration of diabetes was positively associated with the risk of developing DR and that 25-OH-VitD3 concentrations were negatively associated with the risk of developing DR in a nonlinear manner, and the turning points for hazard ratio = 1 were 5.1 years and 10.6 ng/mL, respectively (Fig. 3 and Supplementary Table S3).

The use of the duration of diabetes and 25-OH-VitD3 concentrations for predicting the incidence of DR

The durations of diabetes and 25-OH-VitD3 concentrations were subjected to ROC curve analysis to identify the factors for predicting the incidence of DR. As shown in Table 3; Fig. 4, the combination of the duration of diabetes and 25-OH-VitD3 concentrations showed ideal precision, with a sensitivity, specificity and AUC of 79.4%, 69.4% and 0.764, respectively.

Discussion

In the present study, we found that 29.3% (107/365) of patients in the Tibet Autonomous Region who were hospitalized with T2DM had DR. Moreover, a longer duration of diabetes, lower 25-OH-VitD3 and hemoglobin concentrations, higher fasting insulin concentrations, lower alanine aminotransferase concentrations and higher creatinine concentrations were associated with a

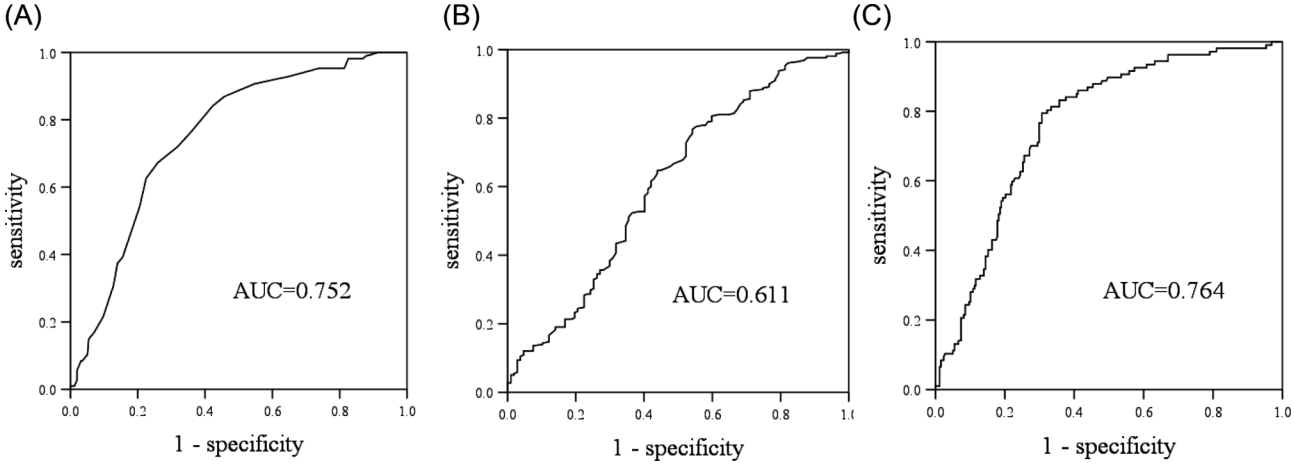

Fig. 4 AUC analysis of the duration of diabetes (**A**), 25-OH-VitD3 concentrations (**B**), and the combination of duration of diabetes and 25-OH-VitD3 concentrations (**C**) for predicting the incidence of DR

greater incidence of DR. In addition, the duration of diabetes and 25-OH-VitD3 concentrations were identified as predictive characteristics of DR.

As a major microvascular complication of diabetes, DR is currently largely responsible for blindness among persons of working age [16]. A previous study reported that the overall prevalence of DR is 22.27% worldwide and highlighted the substantial public health burden and the importance of modifiable risk factors in its occurrence [17]. However, substantial differences were observed among different regions, with the highest prevalence in Africa (35.90%) and North America (33.30%) and the lowest prevalence in South and Central America (13.37%) [17]. Furthermore, the prevalence of DR in China was reported to be 18.45% [18], which was lower than the 29.8% reported in our present study. Ultraviolet light exposure is likely the main cause of the relatively high prevalence. Unprotected and prolonged exposure to ultraviolet light from sunlight, which is common among plateau dwellers, has been shown to lead to retinal damage [19]. In addition, the hospitalized patients with T2DM included in the present study were characterized by poorly controlled blood glucose and a longer duration of diabetes, which may have led to the actual prevalence being overestimated to some degree. Furthermore, the populations and methodologies included in these studies varied, which may be another possible reason.

Similar to the findings of previous studies, a longer duration of diabetes has been shown to be an important variable in the occurrence of DR [20, 21]. Notably, most patients with DR have a duration of T2DM of more than 7 years [21]. In our study, the nonlinear relationship between the duration of diabetes and the risk of developing DR showed that the risk of developing DR significantly increased after diabetes was diagnosed for 5.1 years, suggesting that we need to focus on the time of screening for DR, which can help with early intervention. Hyperglycemia status and higher HbA1c values have been identified as risk factors for the incidence of DR, and DR does not develop in patients with adequate glycemic control [22, 23]. However, our study revealed no association between HbA1c values and the risk of developing DR, which could be explained by hospitalized patients with relatively poor control of blood glucose, characterized by an average HbA1c of 11.8% for all patients combined.

Vitamin D has multiple functions in maintaining human health, and vitamin D deficiency is associated with various diseases, including cancers, autoimmune diseases, diabetes, infectious diseases and hypertension [24, 25]. Vitamin D3 is produced in the epidermal layer of the skin under sunlight exposure or is obtained from the diet. The active forms of vitamin D3, 25-OH-VitD3 and 1, 25-$(OH)_2$-VitD3, require the metabolic functions of the liver and kidneys [26]. In recent years, many observational studies have investigated the correlation between vitamin D concentrations and the risk of developing DR, but the results are not entirely consistent. Most studies reported a negative correlation between vitamin D concentrations and the prevalence or severity of DR [27, 28]. However, studies from China and India reported a lack of association between vitamin D deficiency and the risk of developing DR [29, 30]. Our present study revealed lower levels of 25-OH-VitD3 among patients with DR. The discrepancy in these results may be caused by the different populations, regional characteristics, vitamin D testing methods and polymorphisms of the vitamin D receptor. Importantly, the incidence of DR significantly increased when the 25-OH-VitD3 concentration was less than 10.6 ng/mL, which appears to be the turning point. Therefore, attention should be given to 25-OH-VitD3 levels, and early intervention with supplementation is recommended, especially in patients with severe vitamin D deficiency (which is currently defined as a 25-OH-VitD3 concentration less than 10 ng/mL) [25]. However, further studies are needed to explore optimal 25-OH-VitD3 levels for the prevention of DR, which is critical for public health. Regarding the possible mechanism, a previous study revealed that vitamin D3 attenuates the damage elicited by high glucose concentrations, maintains cell viability and reduces the expression of inflammatory cytokines such as IL-1β and ICAM-1. Furthermore, vitamin D3 preserves blood–retinal barrier integrity [31].

To further clarify the predictive effectiveness of demographic and clinical characteristics for the occurrence of DR among patients with T2DM, AUC parameters, including sensitivity, specificity and AUC, were introduced. The combination of duration of diabetes and 25-OH-VitD3 concentrations presented a sensitivity, specificity and AUC of 79.4%, 69.4% and 0.764, respectively. These findings suggest that these factors may be useful for guiding the early diagnosis and intervention of DR.

There were several limitations in our study. First, as a retrospective study, we included only a single center and had a limited sample of patients with T2DM. Multicenter studies will provide more concrete evidence. Second, we did not differentiate between proliferative DR and nonproliferative DR because of the limited sample size, but the core results were unaffected. Third, no significant correlation was found between altitude and the risk of developing DR in the present study, which may be due to the absence of a low-altitude group for comparison. Future studies should include a low-altitude group to further investigate this issue. Fourth, some potential risk factors of DR, like socioeconomic status, were not discussed in this study and we hope to explore the influence in a prospective study in the further.

Conclusions

Our study revealed that the prevalence of DR was 29.3% among patients hospitalized with T2DM in the Tibet Autonomous Region. In addition, a longer duration of diabetes and lower 25-OH-VitD3 concentrations were identified as independent predictors of DR in this group of patients. It has been proposed that vitamin D supplementation is important in the prevention of DR, and this is crucial for enhancing the quality of life of individuals residing in plateau regions.

Abbreviations

AUC	Area under the curve
DR	Diabetic retinopathy
HbA1c	Glycosylated hemoglobin Alc
LDL-C	Low-density lipoprotein cholesterol
RCS	Restricted cubic spline
ROC	Receiver operating characteristic
T2DM	Type 2 diabetes mellitus
TSH	Thyroid stimulating hormone

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12902-024-01668-4.

Supplementary Material 1

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Author contributions

L.X. and L.Y. made substantial contributions to the conception, study design, and review of the manuscript. C.C., M.S. and W.X. performed the research experiments and statistical analyses and prepared the manuscript. C.W., S.J., Z.Z., Y.L. and T.Q. helped perform the research experiments and analyze the data.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the has been approved by the Ethics Committees of Tibet Autonomous Region People's Hospital (No. ME-TBHP-24-KJ-041) and performed in accordance with the Declaration of Helsinki. Oral informed consent was obtained from all the patients.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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