

Analysis on the Risk Factors of Malnutrition in Type 2 Diabetes Mellitus Patients with Pulmonary Tuberculosis

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Objective: To explore the risk factors of malnutrition in type 2 diabetes mellitus combined with pulmonary tuberculosis (PTB-T2DM) patients and further to provide a clinical research basis for the identification and prevention of malnutrition.

Methods: From January 2020 to February 2022, 307 adult patients diagnosed with PTB-T2DM were enrolled in this retrospective study. According to whether malnutrition occurred after 6 months of treatment, patients were divided into malnutrition group (n = 123) and non-malnutrition group (n = 184). The nutritional status of patients was evaluated according to the Micro-Nutrition Assessment Scale (MNA). Evaluation of indicators was performed, including general information, disease characteristics of PTB-T2DM and laboratory indicators.

Results: Univariate logistic regression analysis showed that drinking, divorced, BMI <18.5kg/m², weight <45kg, waist circumference <79cm, hip circumference <88cm, waist-to-hip ratio <0.99, calf circumference <26cm, grip strength <28kg, NRS score ≥3, Hb <106g/L, Alb <29.00g/L, PA <48.00μmol/L, GHB <3.40%, serum transferrin <1.37 mmol/L, serum potassium <3.18mmol/L, serum sodium <142.95 mmol/L, FEV₁ ≥67.90% and RV <2.89% were risk factors for malnutrition in PTB-T2DM patients (all *P* < 0.05). The results of multivariate logistic regression analysis showed that drinking, divorced, weight <45kg, BMI <18.5kg/m², NRS score ≥3, Hb <106g/L, Alb <29.00g/L, PA <48.00μmol/L, serum transferrin <1.37mmol/L, FEV₁ ≥67.90% and RV <2.89% were independent risk factors for malnutrition in PTB-T2DM patients (all *P* < 0.05).

Conclusion: Drinking, divorced, weight <45kg, BMI <18.5kg/m², NRS score ≥3, Hb <106g/L, Alb <29.00g/L, PA <48.00μmol/L, serum transferrin <1.37mmol/L, FEV₁ ≥67.90% and RV <2.89% may be independent risk factors for malnutrition in PTB-T2DM patients, and timely identification of high-risk groups could improve the prognosis of PTB-T2DM patients.

Keywords: risk factors, malnutrition, type 2 diabetes mellitus, pulmonary tuberculosis

Introduction

Diabetes mellitus (DM) is a metabolic disorder caused by genetic factors, environment and lifestyle, and its mechanism is the defect of insulin secretion or function. In recent years, the prevalence of DM, mainly manifested by hyperglycemia, has increased sharply, reaching 9.7%.¹ In China, type 2 diabetes accounts for 90–95% of all diabetic patients.² Tuberculosis (TB) is a chronic infectious disease caused by *Mycobacterium tuberculosis*,³ and most patients with latent TB infection have no obvious clinical symptoms. When the body's resistance is reduced or cell-mediated immunity is increased, patients with latent TB will develop active TB, of which pulmonary tuberculosis (PTB) is the most common.⁴ China was one of 22 countries with a high TB burden globally, with about 4.5 million active TB patients.⁵ As many as 130,000 TB patients die every year, which was more than twice the total number of other infectious diseases in China.⁵ Type 2 DM is one of the risks to develop TB, and the incidence of type 2 diabetes mellitus combined with pulmonary tuberculosis (PTB-T2DM) showed an increasing trend of 19.3%–24.1%.⁶ These two diseases were closely related and promote each other.⁶ On the one hand, due to high tissue sugar content, metabolic disorders and reduced immune

function, *Mycobacterium tuberculosis* accelerated the reproduction rate and increased the generation of drug-resistant strains, which affected the prognosis of PTB-T2DM patients;⁷ on the other hand, TB can aggravate the disorder of glucose metabolism in T2DM patients, increase the incidence of ketoacidosis, and present a dangerous prognosis.⁷ PTB-T2DM was a new challenge in the field of public health all over the world due to its severity, difficulty in treatment and worse prognosis.⁷

As a chronic wasting disease, patients with PTB-T2DM tend to be in a state of malnutrition, which will impair the body's repair and immune function, thus seriously affecting the prognosis of patients and increasing the risk of disease recurrence.^{8,9} Previous studies reported that the incidence of malnutrition in PTB-T2DM patients is 45%–78.3%.¹⁰ The occurrence of malnutrition in PTB-T2DM patients was caused by several factors. Although T2DM patients had a high concentration of glucose in their tissues, the lack of insulin made the body unable to make full use of glucose for energy and instead decomposed protein and fat for energy, which led to the occurrence of malnutrition. Decreased appetite caused by T2DM led to different degrees of malnutrition.¹¹ In addition, as a chronic wasting disease, PTB also increased catabolism, reduces protein and fat storage, and eventually leads to malnutrition.¹² In addition, T2DM patients had a higher concentration of glucose in their tissues, which was conducive to the growth of *Mycobacterium tuberculosis*, further aggravating the severity.¹¹ Therefore, it was crucial to explore the risk factors of malnutrition in PTB-T2DM patients to improve prognosis and quality of life.¹³ Timely identification of the potential high-risk population for malnutrition in PTB-T2DM patients was beneficial to improve the prognosis of the population. At present, there were few reports on the risk factors of malnutrition in PTB-T2DM patients.

Herein, our study aimed to explore the risk factors of malnutrition in PTB-T2DM patients, and further to provide a clinical research basis for the identification and prevention of malnutrition.

Materials and Methods

Design of the Study

From January 2020 to February 2022, 307 adult patients diagnosed with PTB-T2DM in Beijing Geriatric Hospital were enrolled in this retrospective study. All patients were enrolled according to the order of visit time from earlier to later. They were followed up for 6 months, and their nutritional status was assessed after 6 months of treatment. According to whether malnutrition occurred after 6 months of treatment, patients were divided into malnutrition group ($n = 123$) and non-malnutrition group ($n = 184$). This study protocol was formulated in accordance with the requirements of the Declaration of Helsinki of the World Medical Association. It was approved by the Ethics Committee of Beijing Geriatric Hospital (2018BJLNY-008) (Figure 1).

Inclusion and Exclusion Criteria

Inclusion Criteria

(1) Patient diagnosed with PTB; (2) Patient diagnosed with T2DM; (3) Patients could cooperate to complete the examination, diet intervention and diet record; (4) Patients with good compliance.

Exclusion Criteria

(1) Patients with mental abnormalities; (2) Pregnant patients; (3) Patients with other serious underlying diseases, such as heart disease and hypertension; (4) Patients with malignant tumors; (5) Patients with bronchial asthma who are taking glucocorticoids.

Diagnostic Criteria

The diagnostic criteria for T2DM:¹⁴ The patient presented with classic type 2 diabetes and had an abnormal blood glucose test (random blood glucose ≥ 11.1 mmol/L or fasting blood glucose ≥ 7.0 mmol/L; Or oral glucose tolerance test 2h blood glucose ≥ 11.1 mmol/L).

The diagnostic criteria for PTB:¹⁵ (1) Cough, expectoration, fever and other clinical symptoms, combined with typical manifestations of PTB in chest X-ray and chest CT; (2) Tuberculin skin test (PPD) response ≥ 10 mm; (3) TB antibody positive or γ -interferon release test positive; (4) Smear and culture of mycobacterium were positive; (5) Histopathology is consistent with tuberculous changes and acid fast staining positive.

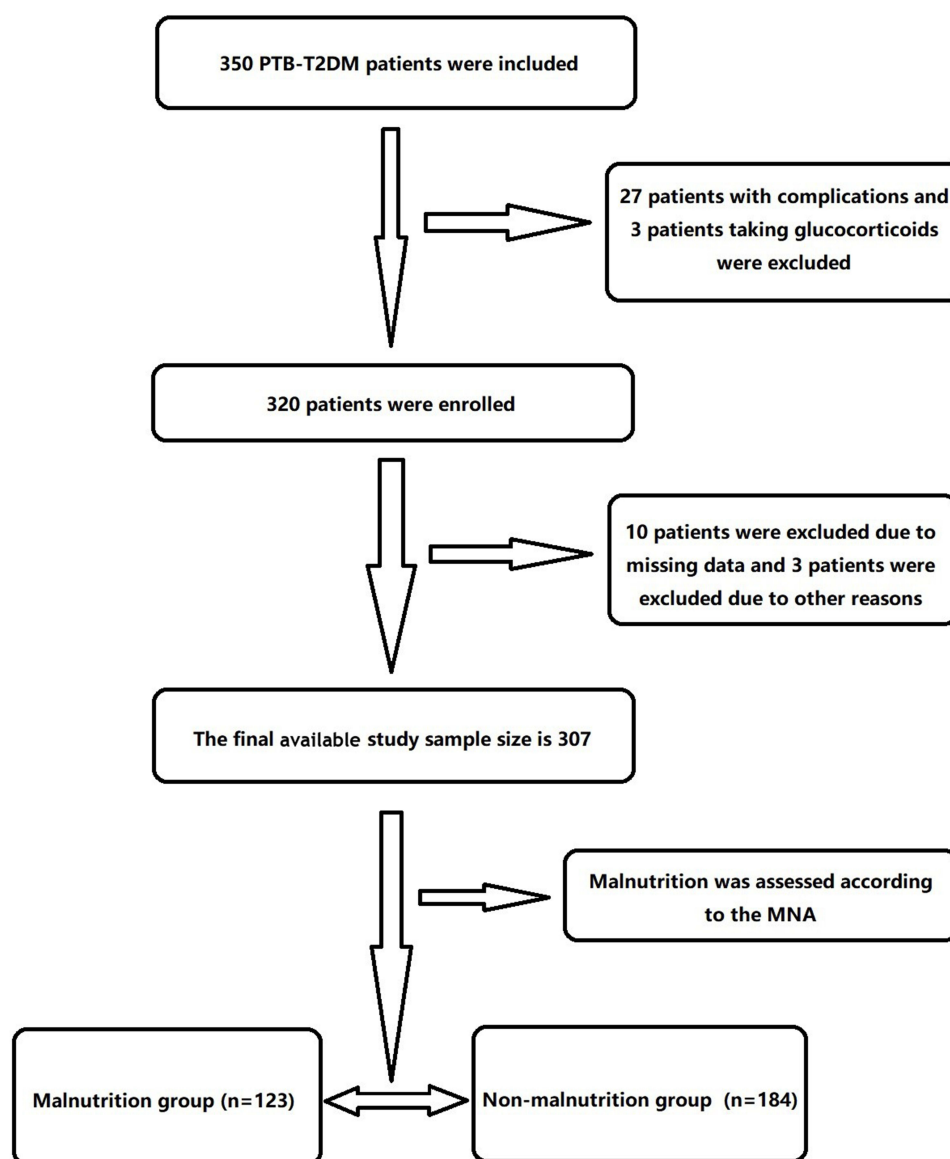


Figure 1 Flow chart of patient enrollment.

Abbreviations: PTB-T2DM, type 2 diabetes mellitus combined with pulmonary tuberculosis; MNA, Micro-Nutrition Assessment Scale.

The nutritional status of patients was evaluated according to the micro Nutrition Assessment Scale (MNA),¹⁶ with a total score of 30 points, which was divided into malnutrition (score <24) and good nutritional status (score ≥24).

Evaluation Index

General information included age, sex, alcohol consumption, smoking, marital status, height, weight, Body Mass Index (BMI), waist circumference, hip circumference, waist-to-hip ratio, calf circumference, grip strength, and Nutritional Risk Screening (NRS) score.¹⁷

Data related to disease characteristics of PTB-T2DM included type of PTB, course of PTB, presence of pulmonary cavity, presence of complications, presence of extrapulmonary TB, and compliance of treatment, the course of T2DM, complications and types of treatment.

Laboratory indicators included hemoglobin (Hb), albumin (Alb), serum prealbumin (PA), neutrophil/lymphocyte ratio (NLR), glycosylated hemoglobin (GHB), fasting blood glucose (FBS), serum transferrin, serum sodium, serum

potassium and pulmonary function parameters [forced vital capacity (FVC), forced expiratory volume second (FEV₁), FEV₁/FVC, maximal voluntary ventilation (MVV), residual volume (RV)].

Specific Method of Measurement

All data were collected by two physicians together after training, and if the data collected by the two physicians differed, the attending physician was asked to measure and assess again to determine.

Height and Weight

Fasting patients, after defecation, take off their coats and shoes and stand on 900Y measuring instrument of height and weight (produced by Henan Lejia Electronic Technology Co., Ltd.). The body was kept upright so that the headrest, buttocks, and heels of both feet remained on the same vertical plane, and the patient's height and weight were measured. BMI was calculated according to height and weight values.

Waist Circumference

The subject's feet were separated by 30–40 cm, the posture was kept upright and breathing smoothly, and measured at the midpoint of the line between the lower rib margin and the anterior superior iliac spine.

Hip Circumference

The subject stood naturally, the buttocks relax, and read the value around a circle at the highest point of the buttocks.

Calf Circumference

The subject's legs were divided, and the circumference was measured with a soft measuring tape in the thickest horizontal position of the lower leg, and the average value of the two lower legs was taken.

Grip Strength

Electronic grip strength meter with uniform correction was used for measurement. Each hand was measured twice, and the average of four determinations was taken.

Pulmonary function tests were performed using the German Jaeger spirometer and measured according to the American Thoracic Society combined with the European Respiratory Society criteria.

Five milliliters of fasting venous blood was taken from all subjects and then centrifuged for examination. BC-5390 automatic hematology analyzer (Shenzhen Mairui Co., LTD, China) and Siemens ADVIA2400 automatic biochemical analyzer (Siemens Co., LTD, Germany) were used for detection.

Statistical Analysis

All the data collected in this study were analyzed using SPSS 23.0 software. The normality of continuous variables was tested by the Shapiro–Wilk test as well as the graphical illustration of histograms and Q–Q plots. Normally distributed measurement data were expressed as mean \pm standard deviation (SD), while non-normally distributed measurement data were expressed as median (interquartile range), and the comparisons were examined by Student's *t*-test and Mann–Whitney test (non-parametric distribution). The categorical data were expressed as *n* (%), and the differences between the two groups were examined by chi-square analysis or Fisher's Exact Test. Univariate/multivariate logistic regression analysis was used to explore the independent risk factors for malnutrition in PTB-T2DM patients, and the results were expressed as odds ratio (OR) and 95% confidence intervals (CIs). The statistical significance level was set at 0.05 for a two-sided test.

Results

Patient Characteristics

A total of 307 patients were enrolled in this study with 177 (57.65%) males and 130 (42.35%) females. The malnutrition group included 184 patients with a median age of 56.92 ± 12.81 years (range 22–73 years). The non-malnutrition group included 123 patients with a median age of 57.12 ± 13.12 years (range 22–72 years).

Univariate Analysis of Malnutrition in PTB-T2DM Patients

All indicators of general information, disease characteristic data and laboratory data were included in the univariate analysis (Table 1). There were significant differences in the indicators of drinking, marital status, BMI, weight, waist circumference, hip circumference, waist-to-hip ratio, calf circumference, grip strength, NRS score, Hb, Alb, PA, NLR, GHB, FBS, serum transferrin, serum sodium, serum potassium, FEV1 and RV between the two groups (all $P < 0.05$). There was no significant difference in other indicators (all $P > 0.05$).

Table 1 Results of Univariate Analysis

Indicators	Malnutrition Group (n = 123)	Non-Malnutrition Group (n = 184)	χ^2/t	P
Age (years)	57.12±13.12	56.92±12.81	-0.133	0.894
Male (%)	74 (60.16%)	103 (55.98%)	0.529	0.467
Drinking (%)	37 (30.08%)	15 (8.15%)	25.198	<0.001
Smoking (%)	7 (5.69%)	4 (2.17%)	2.638	0.104
BMI (kg/m²)	20.09±2.45	23.01±2.38	10.411	<0.001
Marital status				
Married (%)	89 (72.36%)	176 (95.65%)	33.914	<0.001
Unmarried (%)	24 (19.51%)	6 (3.26%)		
Divorced (%)	10 (8.13%)	2 (1.09%)		
Height (cm)	167.34±14.46	168.29±14.28	0.567	0.571
Body weight (kg)	62.19±9.68	67.73±9.76	4.898	<0.001
Waist circumference (cm)	71.09±7.81	76.98±7.98	6.391	<0.001
Hip circumference (cm)	83.29±9.28	103.8±8.92	19.434	<0.001
Waist-to-hip ratio (cm)	0.76±0.06	0.87±0.07	14.271	<0.001
Grip strength (kg)	22.16±2.12	37.05±2.09	60.647	<0.001
Calf circumference (cm)	29.56±4.28	33.43±4.38	7.656	<0.001
NRS score	6.26±0.42	2.39±0.34	-88.831	<0.001
Type of PTB				
Infiltrating type (%)	65 (52.85%)	101 (54.89%)	5.659	0.058
Chronic fibrous void (%)	44 (35.77%)	47 (25.54%)		
Tuberculous pleurisy (%)	14 (11.38%)	36 (19.57%)		
Course of PTB				
Presence of pulmonary cavity (%)	49 (39.84%)	55 (29.89%)	3.256	0.071
Presence of complications (%)	10 (8.13%)	14 (7.61%)	0.028	0.867
Presence of extrapulmonary TB (%)	10 (8.13%)	13 (7.07%)	0.312	0.576
Compliance of treatment				
Take medicine as directed	117 (95.12%)	181 (98.37%)	2.732	0.255
Intermittent treatment	4 (3.25%)	2 (1.09%)		
Never	2 (1.63%)	1 (0.54%)		
Course of DM				
Complications (%)	77 (62.60%)	121 (65.76%)	-0.151	0.883
Types of treatment				
For oral administration	31 (25.20%)	41 (22.28%)	0.225	0.635
Oral administration + insulin	64 (52.03%)	102 (55.43%)		
Oral + insulin + others	28 (22.76%)	41 (22.28%)	0.434	0.805
Hb (g/L)	118.98±13.29	133.98±13.17	9.743	<0.001
Alb (g/L)	36.98±7.98	43.29±8.06	6.749	<0.001
PA (μmol/L)	56.91±7.93	70.87±7.82	15.241	<0.001
NLR (%)	1.72±0.42	2.53±0.47	15.432	<0.001
GHB (%)	3.78±0.39	4.87±0.37	24.492	<0.001
FBS (mmol/L)	3.67±0.43	4.98±0.45	25.672	<0.001
Serum transferrin (g/L)	1.47±0.91	1.83±0.98	3.245	<0.001

(Continued)

Table 1 (Continued).

Indicators	Malnutrition Group (n = 123)	Non-Malnutrition Group (n = 184)	χ^2/t	P
Potassium (mmol/L)	4.11±0.29	4.28±0.32	4.734	<0.001
Sodium (mmol/L)	142.98±2.03	141.83±2.18	-6.881	<0.001
Pulmonary function index				
FVC (%)	81.09±13.19	83.38±13.28	1.485	0.139
FEV ₁ (%)	74.45±10.08	82.21±10.23	6.551	<0.001
FEV ₁ /FVC (%)	88.05±10.53	89.19±10.65	0.923	0.357
MVV (%)	49.93±12.67	52.82±12.89	1.938	0.054
RV (%)	3.32±0.43	2.71±0.34	-13.213	<0.001

Abbreviations: PTB, pulmonary tuberculosis; DM, diabetes mellitus; BMI, body mass index; NRS, Nutritional Risk Screening; Hb, hemoglobin; Alb, albumin; PA, serum prealbumin; NLR, neutrophil/lymphocyte ratio; GHB, glycosylated hemoglobin; FBS, fasting blood glucose; OR, odds ratio; CIs, confidence intervals; FEV₁, forced expiratory volume second; RV, residual volume.

Univariate Logistic Regression Analysis of Malnutrition in PTB-T2DM Patients

With indicators of drinking, divorced, weight <45kg, BMI <18.5kg/m², waist circumference <79cm, hip circumference <88cm, waist-to-hip ratio <69.99, calf circumference <26kg, grip strength <28kg, NRS score ≥3, Hb <106g/L, Alb <29.00g/L, PA <48.00μmol/L, NLR <1.30, GHB <3.40%, FBS <3.24mmol/L, serum transferrin <1.37mmol/L, serum potassium <3.18mmol/L, serum sodium <142.95 mmol/L, FEV₁ ≥67.90% and RV <2.89% as the dependent variable and the presence of malnutrition in PTB-T2DM patients as the independent variable, univariate logistic regression analysis was conducted (Table 2). The results showed that drinking (OR = 2.421, 95% CI = 1.501–3.928), divorced (OR = 6.229, 95% CI = 2.098–10.287), BMI <18.5kg/m² (OR = 3.321, 95% CI = 1.786–5.653), weight <45kg (OR = 1.012, 95% CI = 0.876–1.763), waist circumference <79cm (OR = 5.679, 95% CI = 4.098–11.298), hip circumference <88cm (OR =

Table 2 Univariate Regression Analysis of Malnutrition in PTB-DM Patients

Indicators	Malnutrition Group (n = 123)	Non-Malnutrition Group (n = 184)	OR (95%CI)	P
Drinking (%)	37 (30.08%)	15 (8.15%)	2.421 (1.501–3.928)	0.042
Divorced (%)	10 (8.13%)	2 (1.09%)	6.229 (2.098–10.287)	0.003
BMI <18.5 kg/m ² (%)	98 (79.67%)	29 (15.76%)	3.321 (1.786–5.653)	0.017
Weight <45 kg (%)	99 (80.49%)	26 (14.13%)	1.012 (0.876–1.763)	0.023
Waist circumference <79 cm (%)	87 (70.73%)	22 (11.96%)	5.679 (4.098–11.298)	<0.001
Hip circumference <88 cm (%)	102 (82.93%)	12 (6.52%)	2.769 (1.702–4.289)	<0.001
Waist-hip ratio <69.99 (%)	92 (74.80%)	23 (12.50%)	3.508 (3.109–4.119)	<0.001
Grip strength <26 kg (%)	104 (84.55%)	19 (10.33%)	3.056 (2.781–3.675)	<0.001
Calf circumference <28.00 kg (%)	55 (44.72%)	13 (7.07%)	6.098 (4.719–13.487)	<0.001
NRS score ≥3 points (%)	68 (55.28%)	18 (9.78%)	1.059 (0.873–1.231)	<0.001
Hb <106 g/L (%)	71 (57.72%)	15 (8.15%)	5.219 (2.098–12.136)	<0.001
Alb <29.00 g/L (%)	76 (61.79%)	18 (9.78%)	2.351 (1.542–5.876)	0.027
PA <48.00 μmol/L (%)	64 (52.03%)	17 (9.24%)	6.932 (2.018–19.876)	<0.001
NLR <1.30 (%)	76 (61.79%)	16 (8.70%)	1.061 (0.571–1.932)	0.823
GHB <3.40% (%)	75 (60.98%)	17 (9.24%)	3.529 (1.221–5.098)	0.023
FBS <3.24 mmol/L (%)	73 (59.35%)	17 (9.24%)	4.367 (1.319–6.718)	0.083
Serum transferrin <1.37 mmol/L (%)	78 (63.41%)	15 (8.15%)	3.207 (1.404–4.893)	0.011
Potassium <3.18 mmol/L (%)	81 (65.85%)	18 (9.78%)	1.137 (1.001–1.172)	<0.001
Sodium <142.95 mmol/L (%)	79 (64.23%)	17 (9.24%)	1.092 (0.983–1.231)	<0.001
FEV ₁ ≥67.90% (%)	74 (60.16%)	16 (8.70%)	1.376 (1.071–1.897)	<0.001
RV <2.89% (%)	76 (61.79%)	17 (9.24%)	0.771 (0.683–0.867)	<0.001

Abbreviations: PTB, pulmonary tuberculosis; DM, diabetes mellitus; BMI, body mass index; NRS, Nutritional Risk Screening; Hb, hemoglobin; Alb, albumin; PA, serum prealbumin; NLR, neutrophil/lymphocyte ratio; GHB, glycosylated hemoglobin; FBS, fasting blood glucose; OR, odds ratio; CIs, confidence intervals; FEV₁, forced expiratory volume second; RV, residual volume.

2.769, 95% CI = 1.702–4.289), waist-to-hip ratio <69.99 (OR = 3.508, 95% CI = 3.109–4.119), calf circumference <26kg (OR = 3.056, 95% CI = 2.781–3.675), grip strength <28kg (OR = 6.098, 95% CI = 4.719–13.487), NRS score ≥ 3 (OR = 1.059, 95% CI = 0.873–1.231), Hb <106g/L (OR = 5.219, 95% CI = 2.098–12.136), Alb <29.00g/L (OR = 2.351, 95% CI = 1.542–5.876), PA <48.00 μ mol/L (OR = 6.932, 95% CI = 2.018–19.876), GHB <3.40% (OR = 3.529, 95% CI = 1.221–5.098), serum transferrin <1.37 mmol/L (OR = 3.207, 95% CI = 1.404–4.893), serum potassium <3.18mmol/L (OR = 1.137, 95% CI = 1.001–1.172), serum sodium <142.95 mmol/L (OR = 1.092, 95% CI = 0.983–1.231), FEV₁ $\geq 67.90\%$ (OR = 1.376, 95% CI = 1.071–1.897) and RV <2.89% (OR = 0.771, 95% CI = 0.683–0.867) were risk factors for malnutrition in PTB-T2DM patients (all $P < 0.05$).

Multivariate Logistic Regression Analysis of Malnutrition in PTB-T2DM Patients

Multivariate logistic regression analysis was conducted with the independent variables of drinking, divorced, weight <45kg, BMI <18.5kg/m², waist circumference <79cm, hip circumference <88cm, waist-to-hip ratio <69.99, calf circumference <26kg, grip strength <28kg, NRS score ≥ 3 , Hb <106g/L, Alb <29.00g/L, PA <48.00 μ mol/L, NLR <1.30, GHB <3.40%, FBS <3.24mmol/L, serum transferrin <1.37mmol/L, serum potassium <3.18mmol/L, serum sodium <142.95 mmol/L, FEV₁ $\geq 67.90\%$ and RV <2.89% (Table 3). The results showed that drinking (OR = 2.367, 95% CI = 1.463–3.672), divorced (OR = 1.572, 95% CI = 1.328–1.983), weight <45kg (OR = 3.187, 95% CI = 2.008–3.861), BMI <18.5kg/m² (OR = 3.289, 95% CI = 2.172–5.231), NRS score ≥ 3 (OR = 1.476, 95% CI = 1.201–1.675), Hb <106g/L (OR = 1.982, 95% CI = 0.721–2.342), Alb <29.00g/L (OR = 1.746, 95% CI = 1.028–2.567), PA <48.00 μ mol/L (OR = 2.112, 95% CI = 1.402–3.098), serum transferrin <1.37mmol/L (OR = 1.621, 95% CI = 1.003–2.212), FEV₁ $\geq 67.90\%$ (OR = 0.989, 95% CI = 0.473–1.336) and RV <2.89% (OR = 2.876, 95% CI = 2.018–3.675) were independent risk factors for malnutrition in PTB-T2DM patients (all $P < 0.05$).

Table 3 Multivariate Regression Analysis of Malnutrition in PTB-DM Patients

Indicators	OR (95%CI)	P
Drinking (%)	2.367 (1.463–3.672)	<0.001
Divorced (%)	1.572 (1.328–1.983)	<0.001
BMI <18.5 kg/m ² (%)	3.289 (2.172–5.231)	<0.001
Weight <45 kg (%)	3.187 (2.008–3.861)	<0.001
Waist circumference <79 cm (%)	2.178 (0.998–4.237)	0.059
Hip circumference <88 cm (%)	1.109 (0.928–1.453)	0.627
Waist-hip ratio <69.99 (%)	1.212 (0.976–1.629)	0.119
Grip strength <26 kg (%)	3.217 (0.968–1.764)	0.059
Calf circumference <28.00 kg (%)	1.253 (0.971–1.627)	0.079
NRS score ≥ 3 points (%)	1.476 (1.201–1.675)	<0.001
Hb <106 g/L (%)	1.982 (0.721–2.342)	<0.001
Alb <29.00 g/L (%)	1.746 (1.028–2.567)	<0.001
PA <48.00 μ mol/L (%)	2.112 (1.402–3.098)	<0.001
NLR <1.30 (%)	1.798 (1.092–2.675)	<0.001
GHB <3.40% (%)	3.182 (0.398–8.902)	0.281
FBS <3.24 mmol/L (%)	1.378 (1.035–2.187)	<0.001
Serum transferrin <1.37 mmol/L (%)	1.621 (1.003–2.212)	<0.001
Potassium <3.18 mmol/L (%)	0.947 (0.869–1.376)	0.193
Sodium <142.95 mmol/L (%)	1.048 (0.998–1.109)	0.113
FEV ₁ $\geq 67.90\%$ (%)	0.989 (0.473–1.336)	<0.001
RV <2.89% (%)	2.876 (2.018–3.675)	<0.001

Abbreviations: PTB, pulmonary tuberculosis; DM, diabetes mellitus; BMI, body mass index; NRS, Nutritional Risk Screening; Hb, hemoglobin; Alb, albumin; PA, serum prealbumin; NLR, neutrophil/lymphocyte ratio; GHB, glycosylated hemoglobin; FBS, fasting blood glucose; OR, odds ratio; CIs, confidence intervals; FEV₁, forced expiratory volume second; RV, residual volume.

Discussion

The clinical symptoms of PTB-T2DM patients often be relieved after systematic in-hospital treatment, but in the process of out-of-hospital self-management, poor self-control ability or lack of disease-related knowledge often led to malnutrition and other states, which seriously threatened the prognosis of patients.¹⁸ Previous epidemiological studies have reported a 32.6% incidence of malnutrition in patients with type 2 diabetes and further explored the certainty between MNA scores and clinically common nutritional indicators.¹⁹ Another study involving 539 patients with type 2 diabetes showed that 161 (29.87%) were well nourished, 302 (56.03%) were at risk of malnutrition, and 76 (14.10%) were malnourished.²⁰ Liu's study showed that 69.23% of PTB patients were at risk of malnutrition with an NRS score greater than 3 points,²¹ it was 62.7% in another study.^{21,22} In the present study, the incidence of malnutrition in PTB-T2DM patients was 40.07%, which was similar to previous studies.¹⁰

The univariate analysis showed that there were significant differences in the indicators of drinking, marital status, BMI, weight, waist circumference, hip circumference, waist-to-hip ratio, calf circumference, grip strength, NRS score, Hb, Alb, PA, NLR, GHB, FBS, serum transferrin, serum sodium, serum potassium, FEV₁ and RV between the malnutrition group and non-malnutrition group. The multivariate logistic regression analysis further confirmed that drinking, divorced, weight <45kg, BMI <18.5kg/m², NRS score ≥3, Hb <106g/L, Alb <29.00g/L, PA <48.00μmol/L, serum transferrin <1.37mmol/L, FEV₁ ≥67.90% and RV <2.89% were independent risk factors for malnutrition in PTB-T2DM patients.

Drinking was a key affecting factor for malnutrition in PTB patients, and a risk factor for poor prognosis of PTB.^{23–25} BMI was one of the important indicators to measure the metabolic balance of the body, and most people with low BMI have poor nutrient absorption function.^{26,27} Metabolic dysfunction in PTB-T2DM patients may be a significant factor leading to decreased BMI and severe malnutrition. Multidrug-resistant tuberculosis patients with low BMI often had malnutrition.²⁸ Waist circumference, waist-to-hip ratio and BMI were effective tools for assessing the high-risk status of malnutrition.²⁹ Lower leg circumference values can be used in place of BMI for rapid assessment of malnutrition status.³⁰ The MNA score has screening and assessment functions and has been widely popularized in clinical practice, especially for the screening of malnutrition in elderly patients with chronic diseases.³¹ NRS scores could quickly and easily detect whether patients were combined with malnutrition¹⁷ and were more suitable for screening patients with PTB.^{32,33}

Alb was mainly synthesized by the liver and can maintain the normal transmission of nutrients in the blood. The level of this indicator could reflect the level of blood nutrition to a certain extent.³⁴ The levels of hemoglobin, hematocrit and ALB were decreased in PTB patients with malnutrition.^{35–37} The total content of PA in the body was very small, which can sensitively reflect changes in the body's nutritional status.³⁸ The PA level of PTB patients was reduced, and the abnormal degree of malnutrition was often more obvious.³⁹ PA and transferrin were influencing factors of senile malnutrition.⁴⁰ Changes in GHB were not affected by short-term fluctuations in blood glucose levels.⁴¹ Transferrin was the main ferric protein in plasma, and the change of its expression level was closely related to the body's nutritional status.⁴² GHB and transferrin were closely related to malnutrition in T2DM nephropathy patients undergoing maintenance hemodialysis.⁴³ Decreases in serum potassium and sodium are also factors associated with malnutrition in patients.⁴⁴ In addition, previous studies have shown that PTB patients have reduced pulmonary function, which is closely related to malnutrition.¹⁸

Diet principle of PTB and T2DM existed contradiction. PTB patients need to strengthen their nutrition by increasing their carbohydrate, protein and fat intake without restricting their calorie intake. However, T2DM patients need to strictly control the intake of nutrients due to blood glucose control.⁴⁵ After reviewing the literature, we concluded that the daily intake of total calories should be increased by 10% compared with that of ordinary diabetic patients, including 300–500 g/d carbohydrate, 1.0–1.5 g/d protein and 1 g/d fat.⁴⁵ And limit sodium intake to no more than 3g a day. In addition, active supplementation of various vitamins and trace elements can affect the synthesis, secretion, storage and function of insulin, and also played an important role in the metabolism of energy substances, which could improve the nutritional status of patients and reduce the adverse reactions of anti-TB drugs.⁴⁵

One of the limitations was that the small sample size may weaken the generalisability of the results. Another limitation was that the short follow-up time of 6 months may result in skewed results. In the further study, we will adopt a multicenter randomized controlled study with a larger sample and long-term follow-up to verify the conclusion.

Conclusions

Drinking, divorced, weight <45kg, BMI <18.5kg/m², NRS score ≥ 3 , Hb <106g/L, Alb <29.00g/L, PA <48.00μmol/L, serum transferrin <1.37mmol/L, FEV₁ $\geq 67.90\%$ and RV <2.89% may be independent risk factors for malnutrition in PTB-T2DM patients, and timely identification of high-risk groups could improve the prognosis of PTB-T2DM patients.

Data Sharing Statement

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

This study protocol was formulated in accordance with the requirements of the Declaration of Helsinki of the World Medical Association. It was approved by the Ethics Committee of Beijing Geriatric Hospital. Informed consent was obtained from all the study subjects before enrollment.

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Disclosure

The authors declare that they have no competing interests in this work.

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