

## Original Article

# Feasibility study of imaging diagnosis of diabetes mellitus patients with pulmonary tuberculosis

Wencai Tang\*, Weijin Xing\*, Chuanzi Li, Zhongshi Nie, Mubin Cai

Department of Radiology, The Second Affiliated Hospital of Hainan Medical University, Haikou 570311, Hainan Province, China. \*Equal contributors and co-first authors.

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**Abstract:** Objective: To analyze the feasibility of CT diagnosis for patients with diabetes mellitus (DM) and pulmonary tuberculosis (PTB). Methods: A total of 120 DM patients with PTB in our hospital were included in the combination group, and 50 patients with PTB were included in the PTB group. CT examination was performed in all patients and the diagnostic value of CT was analyzed. Results: No significant difference was found in PTB lesions between the combination group and PTB group ( $P > 0.05$ ). The incidence rates of cavities, necrosis and caseous pneumonia in the combination group were higher than those in the PTB group ( $P < 0.05$ ). In the combination group, the ratios of tuberculosis (TB) in a single pulmonary lobe and two or more pulmonary lobes were 33.33% and 66.67% respectively, while those were 54.00% and 46.00% respectively in the PTB group ( $P < 0.05$ ). No significant difference was found in the number of pulmonary segments in the classification of good, general and poor glycemic control effects ( $P > 0.05$ ). Significant differences were found in the incidence of large flakes of segmental and lobar shadows, bronchial inflation signs, wall-less cavities, multiple cavities, thick-walled cavities, and bronchial TB among classification of good, general and poor glycemic control effects ( $P < 0.05$ ). Conclusion: There are certain differences in CT manifestations between patients with both DM and PTB and patients with PTB. There are certain differences in CT manifestations among DM patients with PTB with good, general and poor glycemic control effects. These results exhibit that when using CT for diagnosis of whether DM patients have PTB can be performed and the glycemic control effects on DM patients can be identified.

**Keywords:** Diabetes mellitus, pulmonary tuberculosis, imaging, CT, diagnosis, feasibility

## Introduction

Pulmonary tuberculosis (PTB) is a common infectious disease, and its occurrence is closely related to the living environment and nutritional status of patients [1]. Diabetes mellitus (DM) is a chronic metabolic disease with a high incidence rate in China. Recently, the incidence rate of DM, especially type 2 diabetes, has been on the rise due to changes in diet and lifestyle [2].

Studies have found that the incidence rate of DM patients with PTB is considerably higher than healthy people with PTB; DM and PTB are closely related they affect each other, and the influence of DM on PTB is greater than that of PTB on DM [3, 4]. DM patients with PTB show no typical symptoms, but they have a high positive rate of cultured Mycobacterium TB. The pulmonary lesions are widely distributed and they are of high severity. It remains very diffi-

cult to diagnose, confirm and treat DM patients with PTB [5]. For the diagnosis of DM patients with PTB, an accurate diagnosis of PTB plays a pivotal role. An observation room was established to monitor the typical symptoms and signs, multiple auxiliary examination methods, such as pulmonary biopsy, fiberoptic bronchoscopy, sputum smear and culture for acid-fast bacilli (AFB), and T-SPOT.TB examination were adopted [6, 7]. In China, the diagnosis of PTB is mainly based on sputum culture or sputum smear, and it is difficult to obtain a high positive detection rate. Additionally, some methods, such as T-SPOT.TB examination, have a higher cost. The PPD test is easily affected by multiple factors. There is some trauma in using the pulmonary biopsy and fiberoptic bronchoscopy, resulting in a low acceptance rate of patients. These factors hinder the promotion and application of the aforementioned methods [8, 9].

## Feasibility of CT diagnosis of DM patients with PTB

Long-term studies suggest that the diagnosis of DM patients with PTB must be comprehensively analyzed based on the symptoms and multiple examination results, so as to ensure as high accuracy as possible. Compared with the aforementioned methods, imaging methods are more feasible. As a common imaging method in clinical diagnosis, CT plays a crucial role in the diagnosis of multiple diseases [10]. However, in previous studies, CT was mostly adopted in the diagnosis of PTB in patients, and very few studies used CT to diagnose DM patients with PTB. In this study, a total of 120 DM patients with PTB and 50 PTB patients in our hospital were selected as the study subjects. The application value of CT in the diagnosis of DM patients with PTB was extensively explored.

### Materials and methods

#### Data

From June 2018 to March 2020, a total of 50 PTB patients (PTB group) and 120 DM patients with PTB (combination group) who were admitted to our hospital were selected as the study subjects. Inclusion criteria: patients who were in line with the diagnostic criteria of PTB: referring to the relevant diagnostic criteria in the Guidelines for the Diagnosis and Treatment of Pulmonary Tuberculosis (2013 Edition). The positive sputum examination was regarded as the positive PTB marker [11]. The diagnostic criteria of type 2 diabetes were: clinical symptoms of DM plus random blood glucose results  $\geq 11.1$  mmol/L, or blood glucose results type 2 mmol/L 2 h after meals, or fasting blood glucose: mmol/L [12]. Patients with complete diagnostic and treatment data; and those with good compliance were included in the study. The consent form was signed by the patient or his/her guardian. The study was approved by the Ethical Committee of The Second Affiliated Hospital of Hainan Medical University. Exclusion criteria: Patients with type 1 diabetes; those who recently received radiotherapy or chemotherapy; those complicated with AIDS; those with an allergic constitution; and those with serious systemic diseases were excluded.

#### Methods

All patients were examined using Philips 128-slice spiral CT scanner, and instructed to hold

their breath after a deep inhalation. The scan was performed when the patients held their breath, with a top-down scan from pulmonary tip to costophrenic angle. Parameter settings: reconstruction interval: 5 mm, reconstruction layer thickness: 5 mm, thin layer reconstruction: 1 mm, reconstruction matrix:  $1024 \times 1024$ , image scanning matrix:  $1024 \times 1024$ , current: 250 mA, voltage: 125 kV. The standard algorithm was selected.

After the examination, two highly qualified physicians from the Imaging Department read the films on PACS, and made unified diagnostic opinions after consultation or discussion with the supervising physicians. The exudation, distribution, proliferation, bronchus, pleural effusion, cavities and lymph nodes of PTB lesion patients were observed and accurately recorded in the registration form.

#### Observation indices

Imaging manifestations: the distribution, features and range of lesions were observed between the combination group and PTB group.

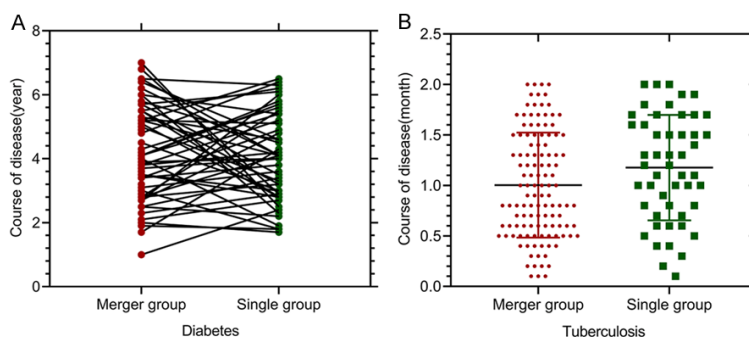
Fasting blood glucose detection: fasting blood glucose level (hexokinase method) was measured using a Hitachi 7600 automatic biochemical analyzer and glucose diagnostic reagent. According to fasting blood glucose, the patients in the combination group were divided into three classifications: the group with good glycemic control (fasting blood glucose level:  $< 7$  mmol/L), the group of general glycemic control (fasting blood glucose level: 7-10 mmol/L), and the group with poor glycemic control (fasting blood glucose level:  $> 10$  mmol/L). The number of pulmonary segments involved, the incidence of large flakes of segmental and lobar shadows, bronchial inflation signs, wall-less cavities, single cavities, multiple cavities, thin-walled cavities, thick-walled cavities, patchy shadows, proliferative nodules, enlarged lymph nodes, pleural effusion and bronchial tuberculosis (BTB) were compared among the three groups.

The analysis standard for CT manifestations of PTB: BTB: CT examination showed that the bronchial wall was thickened, the lesion's range was long, the lumen was narrowed, and the inner wall was irregular. Mediastinal enlarged lymph nodes referred to lymph nodes

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**Table 1.** Comparison of general data between the two groups ( $\bar{x} \pm s$ )/[n (%)]

Data		Combination group (n = 120)	PTB group (n = 50)	t/X <sup>2</sup>	P
Sex	M	72 (60.00)	31 (62.00)	0.059	0.808
	F	48 (40.00)	19 (38.00)		
Age (years)		56.38 ± 15.49	58.41 ± 13.37	0.809	0.420
BMI (kg/m <sup>2</sup> )		21.16 ± 1.39	21.52 ± 1.42	1.529	0.128
Incidence of PTB	Incidence	83 (69.17)	35 (70.00)	0.012	0.914
	Recurrence	37 (30.83)	15 (30.00)		
Course of DM (years)		4.19 ± 2.37	4.26 ± 2.54	0.172	0.864
Course of PTB (months)		1.39 ± 0.57	1.42 ± 0.60	0.308	0.759



**Figure 1.** Comparison of courses between the combination group and the PTB group. There was no significant difference in the course of DM between the PTB group (A) and the combination group ( $P > 0.05$ ). There was no significant difference in the course of PTB between the PTB group (B) and the combination group ( $P > 0.05$ ).

with the largest diameter exceeding 15 mm. Cavity: cavity was formed as a result of the necrosis, liquefaction and drainage of pathological tissues in the lung through the drainage bronchus. Small patchy shadows: CT examination revealed that the plaques in pulmonary lesions were high-density shadows, the density of central lesions was higher than that of the peripheral lesion, and the edge of the lesion was not clearly visible. Centrilobular nodular shadows: they were located in the center of lobule, and the nodule was not connected with the interlobular septum and pleura. CT showed the nodule shadow with a size of 2 mm-8 mm and an unclear edge. Bronchial inflation sign: branch shadows and bright bronchus were visible in large flakes of segmental and lobar pulmonary consolidation shadows. Segmental and lobar consolidation shadows: pathological tissues, such as inflammation, edema and hemorrhage replaced the gas in alveolar cavities to form flaky shadows, and the density of pulmonary segments and the lobar density

increased obviously and the consolidation shadows were uniform.

### Statistical analysis

Statistical analysis was performed using SPSS 23.0. The measurement data were expressed as ( $\bar{x} \pm sd$ ), and the results were compared using the independent sample *t* test. Enumeration data were expressed as [n (%)], results were compared using chi-squared test. The multi-point comparison within the group was analyzed using ANOVA,

and detected using *F* test. Figures were made using Graphpad Prism 8.  $P < 0.05$  indicated a statistically significant difference.

## Results

### General data

There was no statistically significant difference in the male-to-female ratio and the occurrence and recurrence rates of PTB between the combination group and PTB group ( $P > 0.05$ ). There was no significant difference in mean age, mean body mass index (BMI), course of DM and course of PTB between the combination group and PTB group ( $P > 0.05$ ) (Table 1 and Figure 1).

### Distribution of lesions in the combination group and PTB group

There was no statistically significant difference in the ratios of PTB lesions in the anterior segment of the upper lobe, dorsal segment of the

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**Table 2.** Analysis of the distribution of lesions in combination group and single PTB group [n (%)]

Group	Number of patients	Anterior segment of upper lobe	Dorsal segment of lower lobe	Posterior tip of upper lobe	Middle lobe	Basal segment of lower lobe	Lingual segment of upper lobe	Posterior segment of upper lobe
Combination group	120	25 (20.83)	35 (29.17)	50 (41.67)	3 (2.50)	3 (2.50)	2 (1.67)	2 (1.67)
PTB group	50	15 (30.00)	10 (20.00)	21 (42.00)	1 (2.00)	1 (2.00)	1 (2.00)	1 (2.00)
$\chi^2$		1.648	1.524	0.002	0.038	0.038	0.023	0.023
<i>P</i>		0.199	0.217	0.968	0.845	0.845	0.880	0.880

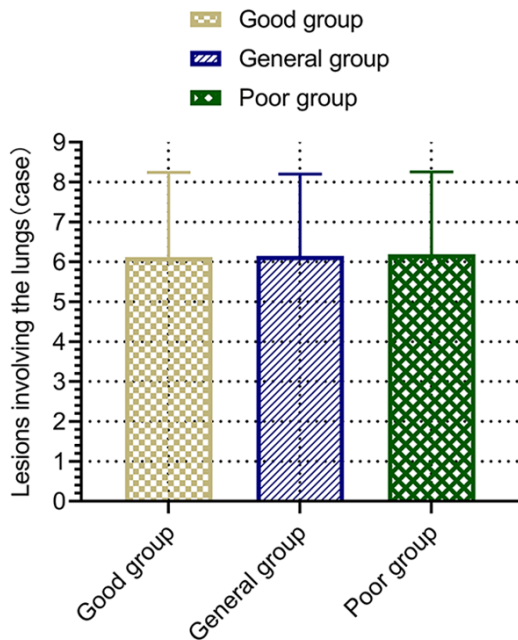
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**Table 3.** Analysis of characteristics of PTB lesions in the combination group and the PTB group [n (%)]

Group	Number of patients	Exudative lesions	Cavities and necrosis	Signs of bronchial dissemination	Caseous pneumonia	Others
Combination group	120	19 (15.83)	46 (38.33)	11 (9.17)	34 (28.33)	10 (8.33)
PTB group	50	14 (28.00)	11 (22.00)	9 (18.00)	7 (14.00)	9 (18.00)
$\chi^2$		3.340	4.225	2.653	3.962	3.322
<i>P</i>		0.068	0.040	0.103	0.047	0.068

**Table 4.** Analysis of the distribution range of PTB lesions in the combination group and the PTB group [n (%)]

Group	Number of patients	In a single pulmonary lobe	In two or more pulmonary lobes
Combination group	120	40 (33.33)	80 (66.67)
PTB group	50	27 (54.00)	23 (46.00)
$\chi^2$		6.313	
<i>P</i>		0.012	



**Figure 2.** Blood glucose control level and lesion-involved pulmonary segments. There was no significant difference in lesion-involved pulmonary segments among the classifications of good, general and poor glycemic control ( $P > 0.05$ ). There was no significant difference in lesion-involved pulmonary segments between the classifications of general and poor glycemic control ( $P > 0.05$ ).

lower lobe, posterior tip of the upper lobe, middle lobe, basal segment of the lower lobe, the lingual segment and posterior segment of the upper lobe between the combination group and PTB group ( $P > 0.05$ ). The ratios of PTB

lesions in the anterior segment of the upper lobe, dorsal segment of the lower lobe and posterior tip of the upper lobe in the combination group and PTB group were significantly higher than those of PTB lesions in middle lobe, basal segment of the lower lobe, lingual segment and posterior segment of the upper lobe in the combination

group and PTB group ( $P < 0.05$ ), and there was a statistically significant difference in the comparison of the aforementioned two ratios (Table 2).

### *Lesion characteristics in the combination group and PTB group*

The incidence rates of cavities and necrosis and caseous pneumonia in the characteristics of PTB lesions in the combination group were higher than those in the PTB group ( $P < 0.05$ ), but there was no significant difference in the incidence rates of exudative lesions, signs of bronchial dissemination and other characteristics between the combination group and PTB group ( $P > 0.05$ ) (Table 3).

### *Distribution range of lesions in combination group and simple PTB group*

The results of the distribution range of PTB lesions in the combination group exhibited that the ratios of PTB lesions in a single lobe and two or more lobes were 33.33% and 66.67% respectively, while those in the PTB group were 54.00% and 46.00% respectively, showing statistically significant differences in the distribution range of PTB lesions between the two groups ( $P < 0.05$ ) (Table 4).

### *Lesion-involved pulmonary segments in patients with different glycemic control effects*

Based on fasting glycemic control effects, the combination group was divided into three clas-

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**Table 5.** CT manifestations of patients with different glyceemic control effects

Manifestations	Group of good glyceemic control effects (n = 50)	Group of general glyceemic control effects (n = 40)	Group of poor glyceemic control effects (n = 30)	F	P
Large flakes of segmental and lobar shadows	20 (40.00)	25 (62.50)	25 (83.33)	5.521	0.008
Bronchial inflation signs	18 (36.00)	24 (60.00)	24 (80.00)	5.489	0.005
Wall-less cavities	15 (30.00)	20 (50.00)	20 (66.67)	4.527	0.002
Single cavities	12 (24.00)	10 (25.00)	8 (26.67)	1.346	0.182
Multiple cavities	10 (20.00)	18 (45.00)	21 (70.00)	5.847	0.009
Thin-walled cavities	7 (14.00)	5 (12.50)	4 (13.33)	0.659	0.261
Thick-walled cavities	10 (20.00)	15 (37.50)	18 (60.00)	5.018	0.008
Small patchy shadows	44 (88.00)	35 (87.50)	26 (86.67)	1.126	0.419
Proliferative nodules	40 (80.00)	33 (82.50)	25 (83.33)	1.074	0.637
Enlarged lymph nodes	4 (8.00)	4 (10.00)	3 (10.00)	0.857	0.411
Pleural effusion	7 (14.00)	5 (12.50)	4 (13.33)	1.063	0.528
Bronchial tuberculosis	11 (22.00)	16 (40.00)	18 (60.00)	6.285	0.000

sifications, namely, the group with good glyceemic control (n = 50), the group with general glyceemic control (n = 40) and the group with poor glyceemic control (n = 30). There were (5.62 ± 4.19) lesions found in pulmonary segments in the group with good glyceemic control, (5.79 ± 4.14) lesions found in the group with general glyceemic control and (6.17 ± 4.27) lesions found in the group with poor glyceemic control. There was no significant difference in the number of pulmonary segments involved in the distribution of lesions among the three groups ( $P > 0.05$ ) (Figure 2).

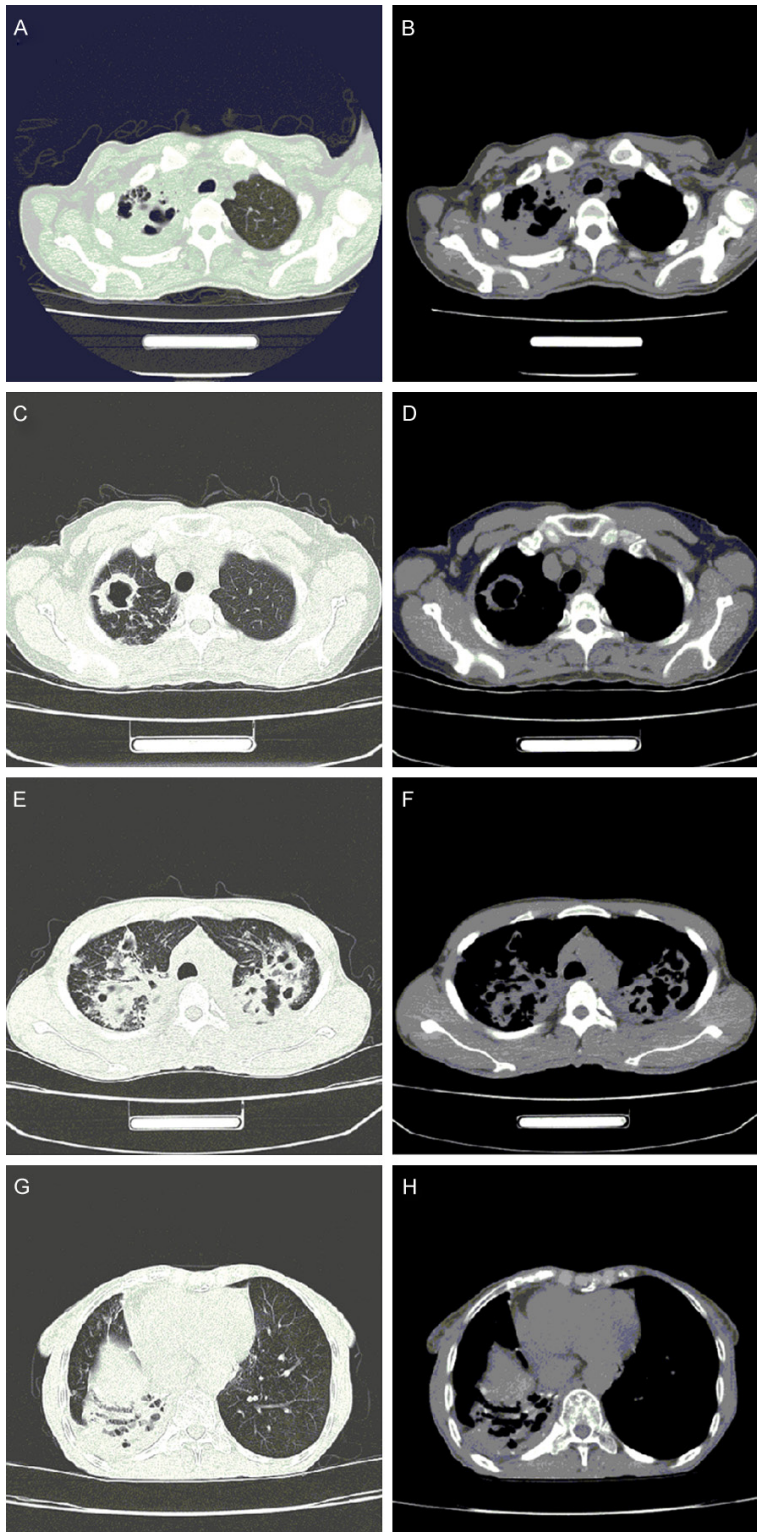
### *CT manifestations in patients with different glyceemic control effects*

According to the statistical results in Table 5, the main CT manifestation found in DM patients with PTB included large flakes of segmental and lobar shadows, small patchy shadows, wall-less cavities (Figure 3A, 3B), thick-walled cavities (Figure 3C, 3D), thin-walled cavities, single cavities, multiple cavities (Figure 3E, 3F), bronchial TB, bronchial inflation signs (Figure 3G, 3H), proliferative nodules, enlarged lymph nodes and pleural effusion. There was a statistically significant difference in the incidence rates of large flakes of segmental and lobar shadows, bronchial inflation signs, wall-less cavities, multiple cavities, thick-walled cavities and bronchial TB among the classifications of good, general and poor glyceemic control effects ( $P < 0.05$ ), but there was no statistically significant difference in the incidence rates of single cavities, thin-walled cavi-

ties, patchy shadows, proliferative nodules, enlarged lymph nodes and pleural effusion among the three groups ( $P > 0.05$ ) (Table 5).

### Discussion

Mycobacterium TB is the major pathogen of TB, and *Mycobacterium bovis* is the primary pathogen of human TB [13]. A study of DM suggests that type 2 diabetes is closely related to immune level and inflammation [14]. The studies of PTB and DM reveal that there are mutual influences between PTB and DM, and the influences of DM on PTB are: impaired glucose regulation in DM patients, continuous accumulation of fructose and sorbitol in the microcirculation that provides the necessary nutrient source for the reproduction of Mycobacterium TB, and DM patients often have different degrees of immune damage, resulting in an elevated infection risk of Mycobacterium TB [15, 16]. Another study exhibited that the continuous high level of blood glucose in DM patients significantly reduces the immune activity of peripheral blood lymphocytes [17]. The influence of PTB on DM includes the occurrence of PTB that leads to glucose intolerance and this affects the glyceemic control in DM patients. During therapy, anti-tuberculosis drugs exert adverse effects on blood glucose. Studies show that isoniazid, an anti-tuberculosis drug, can inhibit liver cell enzymes, leading to the accumulation of active metabolites of glimepiride and elevating the risk of hypoglycemia [18, 19].



**Figure 3.** CT imaging manifestations of DM patients complicated with PTB. The pulmonary window showed the wall-less cavity in the right upper lobe (A), and the mediastinal window revealed the wall-less cavity in the right upper lobe (B). The pulmonary window suggested the thick-walled cavity in the right upper lobe (C), and the mediastinal window showed the thick-walled cavity in the right upper lobe (D). The pulmonary window indicated

multiple cavities of different sizes in the upper lobe of both lungs (E), and the mediastinal window revealed multiple cavities of different sizes in the upper lobes of both lungs (F). The pulmonary window showed the consolidation with bronchial inflation signs in the right lower lobe (G), and the mediastinal window revealed consolidation with bronchial inflation signs in the right lower lobe (H).

Therefore, patients with DM should be regularly examined for prevention and early diagnosis of PTB. The results of this study exhibited that the incidence rates of cavities, necrosis and caseous pneumonia and the ratio of PTB lesions in two or more lung lobes in the combination group were higher than those in the PTB group. This exhibited that there were some differences in CT imaging manifestations between the combination group and PTB group. This suggested that diagnosing DM patients with PTB could be assessed using CT examination results. The aforementioned imaging differences may be related to the recurrence of primary lesions, and may also be caused by inhalation infections as a result of caseous lymphadenitis, or blood and lymphatic infection [20]. Similar studies have also suggested that the ratio of TCR4 and TCR3 cells in the peripheral blood of DM patients with PTB was significantly reduced, and the cellular immunity mediated by T cells was inhibited, which promoted the growth and reproduction of *Mycobacterium TB* and led to the fusion and necrosis of large lesions. In this case, the number of CD8+ T cells increased remarkably, and the

toxic effects of such cells damaged the normal islet tissues. The combination of CD8+ T cells and the cord factor of Mycobacterium TB caused damage to the pulmonary tissue and eventually led to cavities and caseous necrosis [21, 22].

This study also exhibited that there were some differences in CT imaging manifestations of DM patients with PTB with different qualities of glycemic control. The CT imaging manifestations were large flakes of segmental and lobar shadows, bronchial inflation signs, wall-less cavities, multiple cavities, thick-walled cavities and bronchial TB, and they gradually increased with the decrease of blood glucose level control quality ( $P < 0.05$ ). A similar study also found that the increase in glucose concentration was positively correlated with severity of TB at a certain concentration, that is, a higher glucose concentration indicated higher severity of PTB [23]. This indicated that higher fasting blood glucose levels of DM patients indicated a higher severity of TB lesions after DM patients were complicated with PTB. This revealed that the blood glucose level control quality in DM patients with PTB could be assessed using CT examination, and the degree of PTB could be judged by measuring blood glucose levels. DM complicated with PTB is generally an active condition, and it can develop rapidly as a result of the decrease in immunity of DM patients with PTB [24]. The weakened cellular immune functions of DM patients, reduced epithelial-like cells, gradually enlarged lesions of caseous necrosis, and gradually increased infection of Mycobacterium TB or even completely lost cellular immunity leads to a wide array of caseous necrosis [25]. Higher fasting blood glucose levels of DM patients indicates a higher incidence of bronchial issues. This may be due to the low immunity and rapid progression of disease in DM patients with PTB. A large number of inflammatory exudates replaces the gas originally existing in alveoli, and the pulmonary tissues have caseous consolidation [26].

In summary, there are certain differences in CT manifestations between patients with DM and PTB and PTB alone. There are certain differences in CT manifestations among DM patients with PTB with good, general and poor glycemic control effects. This indicates that using CT, the diagnosis of whether DM patients

have PTB can be performed and the glycemic control effects on DM patients can be identified. However, the number of subjects enrolled in this study is insufficient, and the manifestations of PTB are classified based on different blood glucose levels, while the analysis of DM was not performed based on PTB. There is a lack of comprehensiveness in the analysis of the study results, and the results obtained may be biased to some extent. In the future, we will conduct more in-depth studies with a larger sample size and focus on prospective studies, so as to obtain more scientific study conclusions, thus providing better references for the diagnosis and treatment of DM patients with PTB.

### Disclosure of conflict of interest:

None.

**Address correspondence to:** Mubin Cai, Department of Radiology, The Second Affiliated Hospital of Hainan Medical University, No. 48, Baishuitang Road, Longhua District, Haikou 570311, Hainan Province, China. Tel: +86-0898-65399087; E-mail: zyh14a@163.com

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