Incidence, laboratory diagnosis and predictors of tracheobronchial tuberculosis in patients with pulmonary tuberculosis in Chongqing, China

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Abstract. Tracheobronchial tuberculosis (TBTB) is reported in 10-40% of patients with pulmonary tuberculosis (PTB). Due to its non-specific presentation, the diagnosis and management are frequently delayed. The aim of the present study was to investigate the incidence, predictors and laboratory diagnosis of concomitant TBTB and PTB in Chongqing, China. Bronchoscopy was performed in all patients with newly diagnosed or relapsed PTB in order to detect TBTB between January 2018 and April 2019 in a sub-tertiary hospital in Chongqing, China. The clinical characteristics and laboratory data were analyzed to identify predictors and determine the diagnostic yield of TBTB. A total of 341 (31.4%) of the 1,085 patients with PTB who underwent the bronchoscopic examination presented with concomitant TBTB. The parameters of female sex [odds ratio (OR)=2.57], clinical symptoms (OR=6.26) and atelectasis (OR=4.3) were independent predictors of TBTB. Cough (OR=32.48) and atelectasis (OR=3.14) were independent predictors of TBTB-associated tracheobronchial stenosis. The diagnostic yields of sputum smear, bronchial brush smear, sputum culture, GeneXpert *Mycobacterium tuberculosis*/rifampicin resistance (GX) using sputum, GX using brushings and in bronchial brush culture used for the diagnosis of TBTB were 44.2, 44.2, 63.5, 57.7, 71.2 and 75%, respectively. GX brushings had higher diagnostic yields compared with sputum or brush smears; however, there was no significant difference between sputum/brushings cultures and GX with sputum. The incidence of TBTB in PTB was 31.4% in Chongqing, China. The parameters of female sex, atelectasis and cough were the major predictors of concomitant TBTB and associated tracheobronchial stenosis. Although GX is an accurate and rapid test to detect TBTB, additional laboratory techniques should also be adopted to improve diagnostic yields in the detection of TBTB in patients with PTB.

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Abbreviations: AFB, acid-fast bacilli; PTB, pulmonary tuberculosis; TBTB, tracheobronchial tuberculosis; OR, odds ratio; MTB, *Mycobacterium tuberculosis*; GX/RIF, GeneXpert MTB/rifampicin resistance

Key words: tracheobronchial tuberculosis, tracheobronchial stenosis, laboratory diagnosis, incidence, predictor

Introduction

Tuberculosis (TB) is one of the top 10 causes of death and a leading cause of death among several infectious diseases worldwide. In 2018, TB caused ~1.2 million deaths among human immunodeficiency virus (HIV)-negative subjects (1). In China, it was estimated that 866,000 individuals developed TB in 2018 (1). It is important to note that the incidence of TB is higher in the western region compared with the corresponding incidence noted in the eastern and central regions of China (2). In the Chongqing province, which is located in the southwest of China, 23,518 cases of TB were reported in 2017 (3), suggesting that this disease poses a significant threat to public health. The disease incidence ranks in the 18th place compared with other diseases in that state. Although the Chongqing government has adopted several strategies to control TB transmission, the disease burden is still substantial and may correlate with the socioeconomic status, population density and whether the population is rural or urban (4-7).

Tracheobronchial TB (TBTB) is defined as a tuberculous infection of the tracheobronchial tree (8). The exact pathogenesis of TBTB remains to be elucidated. In addition, the detection of *Mycobacterium tuberculosis* (MTB) in TBTB patients with negative sputum acid-fast *bacillus* by traditional bacteriology techniques is difficult and time-consuming. Tracheobronchial stenosis is the most serious complication of TBTB and its incidence may reach 68% within 6 months in the course of the disease and >90% in the long term (9,10).

This process may irreversibly damage lung physiology and eventually result in respiratory failure and death.

To the best of our knowledge, only a limited number of studies have been performed on the application of epidemiological diagnostic yields and predictors of TBTB (11-13). Therefore, the present retrospective observational study performed in Chongqing, China aimed to explore the incidence and laboratory yields of TBTB among patients with pulmonary tuberculosis (PTB) and to report the predictors of TBTB and associated tracheobronchial stenosis. The present study may be considered an expansion to the previous studies performed on TBTB.

Materials and methods

Study procedures. Between January 2018 and April 2019, a total of 1,085 patients with newly diagnosed PTB or relapsed PTB were retrospectively enrolled. The patients were examined by bronchoscopy at the Public Health Medical Center (PHMC), a sub-tertiary hospital in Chongqing, China. The PHMC is the largest infectious disease hospital in Chongqing, which serves as a University teaching hospital for medical universities and takes responsibility for the treatment and prevention of TB in the city. Demographic information, selected laboratory tests, chest CT, clinical data, a medical history of PTB, anti-TB treatment and bronchoscopic findings were obtained, collected and analyzed. The following patient categories were excluded: i) Patients with GeneXpert MTB/rifampicin resistance (GX)-negative and smear- and culture-negative TB; ii) patients aged <18 or >80 years; iii) patients with positive HIV tests; iv) patients with malignancy and survival of <6 months at first presentation at the center; and v) patients with contraindications to bronchoscopy. The present study was approved by the Medical Ethics Committee of the Chongqing PHMC. Written informed consent forms was obtained from all patients. The current study did not include any prospective enrollment of the patients in any trial.

Diagnostic criteria for TB and TBTB. The WHO (1) diagnostic criteria for TB was used in the current study (1). Currently, there is no gold standard for diagnosing for TBTB. The current study adopted the TBTB diagnosis and treatment guidelines from China (14). i) Clinical features of TB; ii) positive acid-fast bacilli or mycobacterial nuclear amplification test in a sputum smear, brush smear or bronchial alveolar lavage fluid; iii) positive *Mycobacterium tuberculosis* culture; iv) visible tracheobronchial lesions under bronchoscopy; and v) bronchoscopic biopsy.

Bronchoscopic examination. All patients with PTB enrolled were examined by bronchoscopy to identify whether they had endobronchial lesions and bronchial brushings were performed on those lesions. According to the Chinese guidelines for the classification of TBTB (14), bronchoscopic subtypes of TBTB may be classified as inflammatory infiltration, ulceration necrosis, granulation hyperplasia, cicatrices stricture, tracheobronchialmalacia and lymph fistula. Following detection of the tracheobronchial lesion, the exact location, subtypes and the number of lesions involved were recorded by the medical practitioners.

The endobronchial stenosis was measured by comparing the area and grade as follows: Grade 1, luminal stenosis <1/3; Grade 2, luminal stenosis ≥1/3 but <2/3; Grade 3, luminal stenosis ≥2/3.

Clinical samples. Specimens from the respiratory tract were obtained from 52 patients with TBTB who had not received any previous anti-TB therapy. A total of 52 clinical samples were analyzed by sputum smear, brush smear, GX for sputum, GX for brushings, sputum culture and brushings culture.

Laboratory examination. The sputum smears and bronchoscopic brush smears were decontaminated using the N-acetyl-L-cysteine sodium hydroxide method (Kubica method) (15). Following decontamination, the sputum smears and brush smears were prepared using the acid-fast bacilli (AFB) method and the rapid auramine O fluorescent stain. Sputum and brushing samples were inoculated onto Lowenstein-Jensen solid medium and in mycobacterial growth indicator tube liquid medium (BD Biosciences) in order to detect bacterial growth.

GeneXpert MTB/RIF assay procedure. The GX assay was performed according to the protocol of a previous study (16). The sample reagent was mixed with the sample at a proportion of 3:1. The sample container was manually vortexed twice during the 15-min incubation period at room temperature. Following processing, 2 ml of the mixed sample was transferred to the cartridge. The cartridge was inserted into the GeneXpert device and the results were automatically generated within 1-2 h.

Statistical analysis. Statistical analysis was performed using SPSS version 22.0 software (IBM Corp.). According to the specific requirements of the study, certain continuous variables were converted into categorical variables. Normally distributed numerical data were presented as medians (interquartile range) and analyzed using an unpaired Student's t-test. The χ^2 test was used to compare the differences between categorical patient characteristics. Modified Bonferroni corrections were performed to controls for multiple comparisons. Univariate and multivariate binary logistic regression analysis was used to determine the predictors of TBTB and tracheobronchial stenosis. $P<0.05$ was considered to indicate statistical significance.

Results

Incidence and bronchoscopic features of TBTB. A total of 1,700 patients with PTB were enrolled, of whom 615 did not undergo bronchoscopic examination as they either did not consent or due to hypoxemia or respiratory failure. A total of 341 (31.4%) patients with PTB undergoing bronchoscopic examination presented with concomitant TBTB, including 107 (18.7%) male and 234 (45.3%) female subjects. The flow chart of the study is presented in Fig. 1. The bronchoscopic features of TBTB are provided in Table I. In the present study, lobe bronchus was mainly noted in patients with MTB. In addition, involvement of the main bronchus and the trachea was noted in patients with MTB. The left main bronchus was

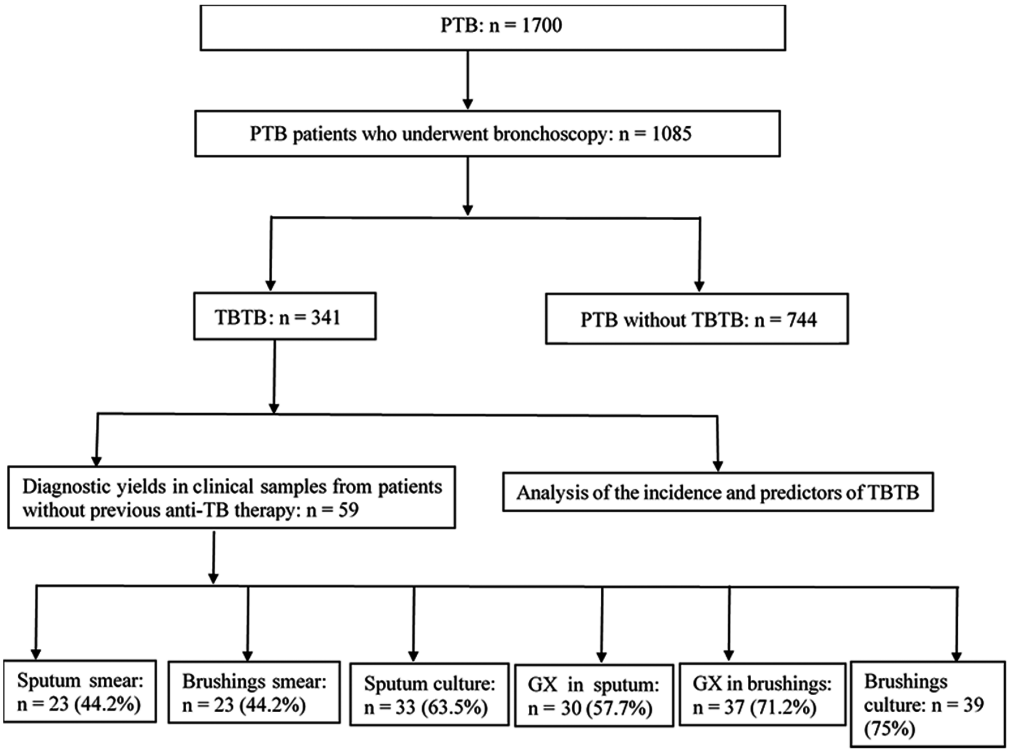

Figure 1. Flow chart of the study. PTB, pulmonary tuberculosis; TBTB, tracheobronchial tuberculosis; GX, GeneXpert *Mycobacterium tuberculosis*/rifampicin resistance.

more prone to be involved in MTB infection compared with the right main bronchus. The majority of the patients with TBTB (54.2%) examined by bronchoscopy presented with only a single lesion and had the highest possible grade of tracheobronchial stenosis (56.1%).

Yields of laboratory methods for TBTB diagnosis. The sputum smear had the same diagnostic yield as the bronchial brush smear (Table II). GX using brushings produced higher diagnostic yields compared with those of either the sputum smear or the brush smear ($P<0.0125$). Analysis was performed for 29 patients with TBTB who were sputum smear-negative and data indicated that the diagnostic yield of GX with sputum and brushing samples was 37.9 and 58.6%, respectively. Furthermore, among the 22 patients with TBTB who were AFB-negative when examined using the sputum smear and the brushing smear techniques, the diagnostic yields for GX with sputum and brushing samples were 36.4 and 50%, respectively (data not shown).

The diagnostic yield of GX using sputum or bronchial brushings was not significantly different compared with that of the sputum culture or brushings culture (Table II). Furthermore, no significant differences were noted for GX using sputum and bronchial brushings.

Clinical characteristics of patients with TBTB. The baseline clinical characteristics of the 744 patients with PTB and the 341 patients with PTB and concomitant TBTB are presented in Table III. The median age of the total patients was 32 years (range, 18-77 years), whereas the median age of the patients with TBTB was 30 years (range, 18-74 years). In the total patient population, young patients (74.6%, age <50 years) were the majority of the patients and the sex ratio of the whole population sample was about equal (data not shown). Among

Table I. Bronchoscopic features of TBTB.

Bronchoscopic feature	n (%)
Type of TBTB	
Inflammatory infiltration	65 (19.1)
Ulceration necrosis	58 (17.0)
Granulation hyperplasia	31 (9.1)
Cicatrices stricture	176 (51.6)
Tracheobronchialmalacia	8 (2.4)
Lymph fistula	3 (0.8)
Site of lesions	
Trachea	124 (36.4)
Left main bronchus	102 (29.9)
Right main bronchus	57 (16.7)
Upper lobe bronchus	236 (69.2)
Lower lobe bronchus	101 (29.6)
Number of lesions involved	
Single	185 (54.2)
Multiple	156 (45.8)
Grade of tracheobronchial stenosis (n=276)	
1	44 (16.0)
2	77 (27.9)
3	155 (56.1)

TBTB, tracheobronchial tuberculosis.

Table II. Comparison of diagnostic yields of different laboratory methods.

	Diagnostic yield (%/totals)				
Method A vs. B	Method A	Method B	χ^2	P-value	Corrected P-value
Sputum smear vs. sputum culture	44.2 (23/52)	63.5 (33/52)	3.896	0.049[a]	0.025
Brushings smear vs. GX in sputum	44.2 (23/52)	57.7 (30/52)	1.885	0.170[a]	0.025
GX in sputum vs. GX in brushings	57.7 (30/52)	71.2 (37/52)	2.056	0.150[b]	0.0125[b]
Sputum culture vs. GX in brushings	63.5 (33/52)	71.2 (37/52)	0.699	0.403[b]	
Brushings smear vs. GX in brushings	71.2 (37/52)	44.2 (23/52)	7.721	0.005[b]	
Brushings culture vs. GX in brushings	75 (39/52)	71.2 (37/52)	0.195	0.658[b]	

[a]P<0.025 (0.05/2) was considered to indicate statistical significance; [b]P<0.0125 (0.05/4) was considered to indicate statistical significance. GX, GeneXpert *Mycobacterium tuberculosis*/rifampicin resistance.

patients with TBTB, female patients were more frequently diagnosed than males (P<0.001). The majority of the female patients were young (n=198; age <50 years). Furthermore, TBTB occurred more frequently in patients with longer symptom duration (>4 weeks).

Additionally, patients with non-smoking history exhibited a higher incidence of TBTB compared with patients with a smoking history (all P<0.001; Table III). The parameters of age and history of TB did not exhibit any significant differences between the two groups. Regarding the findings on CT imaging, the ratio of patients with TBTB who presented with atelectasis was higher compared with that of patients without TBTB (8.8 vs. 2.0%, respectively; P<0.001). However, no significant differences were noted regarding the presence of cavity lesions between the two groups (P=0.16). In addition, cough was the major symptom noted in the two groups and the patients with TBTB exhibited a higher incidence of cough than the patients without TBTB (92.1 vs. 65.6%, respectively; P<0.001).

Predictors of TBTB. Univariate logistic regression analysis indicated that the factors of female sex, clinical symptoms, no history of smoking, symptom duration of ≥4 weeks and atelectasis on CT were predictors of TBTB. Multivariate regression analysis revealed that the factors of female sex [odds ratio (OR), 2.57; 95% CI, 1.82-3.63; P<0.001], clinical symptoms (OR, 6.26; 95% CI, 4.02-9.74; P<0.001), no history of smoking (OR, 0.51; 95% CI, 0.34-0.79; P<0.002) and atelectasis on CT (OR, 4.30; 95% CI, 2.12-8.71; P<0.001) were independent predictors of TBTB (Table IV).

In addition, the risk factors for grade 2 or grade 3 tracheobronchial stenosis were analyzed. The factors of female sex, cough, symptom duration of ≥4 weeks and atelectasis were identified as risk factors for grade 2 or 3 tracheobronchial stenosis on univariate analysis. However, only the parameters cough and atelectasis were significant independent risk factors for grade 2 or 3 tracheobronchial stenosis on multivariate regression analysis (Table V).

Discussion

The present study was the first retrospective research report investigating the incidence, predictors and laboratory diagnosis of TBTB in Chongqing, China. Chongqing is a city in the southwest of China with a population of 33 million. Approximately 23,518 cases of TB were reported in Chongqing in 2017, accounting for 2.7% of all notified TB cases in China (3). However, the incidence of TBTB in Chongqing has remained to be fully determined. In the present study, 31.4% of cases of PTB were combined with TBTB, of which 80.9% had a varying degree of tracheobronchial stenosis.

To the best of our knowledge, a limited number of studies have been performed on the diagnostic yield of TBTB. It is generally accepted that bacterial culture examination is the first step to confirm TBTB and that sputum samples for bacterial culture are easy to obtain. However, the diagnostic yield of AFB from sputum samples in patients with TBTB is only 0-53% (11,17,18). Based on the low sensitivity of microscopy and the time-consuming nature of the culture techniques, GX was initially recommended by the World Health Organization in 2010 and it is currently used for detecting pulmonary and extrapulmonary TB and rifampicin resistance in both adults and children (19). The sensitivity of GX for detecting MTB in patients with TBTB has been previously estimated to be 57.3% for bronchoscopic brushings (18). In the present study, it was determined to be 71.2%. The results indicated that GX using brushings samples exhibited a significantly higher diagnostic yield than that of sputum smear and brushing smear tests. However, the diagnostic yields of GX using brushings and sputum demonstrated no significant difference, which suggested that GX in sputum may lead to improvement in the yield similar to that noted in the bronchial brushings. This result provides important insight that may be used to simplify the diagnosis of TBTB, since sputum may be obtained conveniently and in a non-invasive manner. A positive GX result in the sputum may spare patients from undergoing bronchoscopy, which includes additional costs and risks. Furthermore, the diagnostic yield of the sputum/brushing culture and of GX in brushings revealed no significant differences, which indicated that GX may be an effective initial diagnostic tool for TBTB patients. Therefore, the results suggested that in TBTB brushings, GX is more sensitive than sputum smears and bronchial brushing smears and may enable more rapid TBTB diagnosis. However, GeneXpert MTB/RIF is expensive and patients in poorer areas of the world may not be able to afford this procedure.

Table III. Clinical characteristics of 1,085 patients with pulmonary TB.

Characteristic	Total (n=1,085)	TBTB (-) (n=744)	TBTB (+) (n=341)	P-value
Age (years)	32 (18-77)	33 (18-77)	30 (18-74)	0.88
Sex				<0.001
Male	572 (52.7)	465 (62.5)	107 (31.4)	
Female	513 (47.3)	279 (37.5)	234 (68.6)	
Female (<50 years)	409 (37.7)	220 (29.6)	189 (55.4)	
Duration of clinical symptoms (weeks)				<0.001
<4	208 (19.2)	167 (22.5)	41 (12.0)	
≥4	877 (80.8)	577 (77.5)	300 (88.0)	
Smoking history				<0.001
Yes	336 (30.1)	282 (37.9)	54 (15.8)	
No	749 (69.9)	462 (62.1)	287 (84.2)	
History of TB				0.80
Yes	578 (53.3)	383 (51.5)	195 (57.2)	
No	507 (46.7)	361 (48.5)	146 (42.8)	
CT imaging findings				
Cavitary lesions				0.16
Yes	278 (25.6)	200 (26.9)	78 (22.9)	
No	807 (74.4)	544 (73.1)	263 (77.1)	
Atelectasis				<0.001
Yes	45 (4.2)	15 (2.0)	30 (8.8)	
No	1,040 (95.8)	729 (98.0)	311 (91.2)	
Major clinical symptoms				<0.001
Cough	801 (73.8)	487 (65.6)	314 (92.1)	
Others	214 (19.7)	191 (25.7)	23 (6.7)	
Asymptomatic	70 (6.5)	65 (8.7)	5 (1.4)	

Values are expressed as the median (range) or n (%). TBTB, tracheobronchial tuberculosis.

To date, the pathological processes of TBTB have remained to be fully elucidated and its risk factors are controversial. Therefore, the type of patients with PTB with an increased risk of TBTB and who should be examined for this in particular should be further investigated. The results of the present study revealed that in patients with PTB, female sex, lung atelectasis or cough were associated with an increased probability of concomitant TBTB, suggesting that those patients in particular required bronchoscopic examination for the detection of concomitant TBTB.

In the present study, the average age at TB diagnosis was relatively young (median age, 32 years; range, 18-77 years). However, TB is an immune-associated disease and elderly individuals may be expected to be particularly susceptible to it (1). A possible explanation for this result may be that most TB patients with suspected TBTB in the current study who were examined by bronchoscopy should be in a stable condition and accordingly, young patients accounted for the majority of the population sample. However, age was not considered a predictor of TBTB in the current study. Furthermore, undergoing the bronchoscopic examination is uncomfortable and costly for older individuals and, therefore, certain older patients refused to undergo bronchoscopic examination in the current study. The present results indicated that female patients with TB were more prone to having TBTB than male patients and that sex was an independent risk factor for concomitant TBTB and tracheobronchial stenosis, which is consistent with previous studies (12,13,20). Several possible reasons may explain why female patients were more likely to present with TBTB including the bronchial structure, as well as sociocultural and aesthetic factors (21). Moreover, there is evidence for age-, sex- and population-specific effects on genetic susceptibility to TB (22-24). Therefore, whether sex has an effect on genetic susceptibility to TBTB should be further explored. The possible reasons why young females were more likely to suffer from TBTB in the current study may be the immune response and the endocrine status of the subjects. Type 17 T-helper (Th17) cells belong to a $CD4^+$ T-cell subset that is distinct from the Th1 and Th2 subsets. Th17 cells have effective proinflammatory functions by the production of the cytokines interleukin (IL)-17A and IL-17F (25). Studies have revealed that Th-17 cells are the major IL-17-producing cells and participate in the protective immunity against MTB (26-28). IL-6 has an important role in regulating the balance between IL-17-producing

Table IV. Predictors of tracheobronchial TB.

	Univariate			Multivariate[a]		
Factor	OR	95% CI	P-value	OR	95% CI	P-value
Female sex	3.64	2.75-4.79	<0.001	2.57	1.82-3.63	<0.001
Age ≥50 years	0.71	0.53-0.97	0.30	0.75	0.54-1.05	0.96
Clinical symptoms	6.06	3.98-9.24	<0.001	6.26	4.02-9.74	<0.001
No history of smoking	0.30	0.22-0.43	<0.001	0.51	0.34-0.79	0.002
Symptom duration of ≥4 weeks	2.07	1.44-2.99	<0.001	1.46	0.95-2.25	0.085
Cavity lesion on CT	0.80	0.59-1.09	0.161	0.88	0.63-1.24	0.474
Atelectasis on CT	4.68	2.49-8.84	<0.001	4.30	2.12-8.71	<0.001
History of TB	1.26	0.97-1.64	0.076	1.03	0.76-1.40	0.843

[a]Adjusted by all other variables in the table. TB, tuberculosis; OR, odds ratio.

Table V. Predictors of grade 2 or 3 tracheobronchial stenosis in tracheobronchial TB.

	Univariate			Multivariate[a]		
Variables	OR	95% CI	P-value	OR	95% CI	P-value
Female sex	1.67	1.04-2.70	0.035	1.26	0.69-2.30	0.447
Age ≥50 years	0.74	0.44-1.28	0.692	0.71	0.40-1.28	0.258
Cough	3.40	1.52-7.61	0.003	2.48	1.02-6.06	0.046
No history of smoking	0.62	0.34-1.14	0.123	0.66	0.31-1.42	0.291
Symptom duration of ≥4 weeks	2.48	1.29-4.82	0.007	1.97	0.91-4.32	0.087
Cavity lesion on CT	0.65	0.39-1.10	0.109	0.75	0.43-1.32	0.321
Atelectasis on CT	3.36	1.14-9.88	0.028	3.14	1.05-9.40	0.041
History of TB	1.25	0.79-1.97	0.338	1.03	0.63-1.72	0.881

[a]Adjusted by all other variables in the table. TB, tuberculosis; OR, odds ratio.

Th17 cells and regulatory T cells. The control of the activities of IL-6 is able to inhibit Th17 differentiation and downregulate the levels of IL-17 (29). IL-6 has been suggested to be modulated by estrogens. In postmenopausal females, a negative association was noted between IL-6 levels and plasma estradiol and compared with that in premenopausal females and IL-6 levels were significantly higher (30). This may be the possible reason why young females were more susceptible to TBTB. However, additional clinical trials are required to confirm this hypothesis. It is interesting to note that no history of smoking was an independent risk factor for concomitant TBTB, which is consistent with the results of Su *et al* (13); a possible explanation is that smoking may produce changes in the airway epithelium, thereby preventing MTB from growing in the airways (13). Certain studies have indicated that a longer clinical symptom duration may correlate with longer exposure to *Myobacterium tuberculosis* and contribute to the development of TBTB (12,13). In the present study, the parameter of longer clinical symptom duration was associated with concomitant TBTB, as determined by univariate analysis. However, this parameter was not an independent significant risk factor in the multivariate analysis.

TBTB may contribute to bronchial stenosis formation caused by repeated unhealed scars, which may lead to partial or total lung atelectasis (31,32) and finally cause lung deterioration (33). Jung *et al* (12) conducted a univariate analysis and demonstrated that atelectasis was a risk factor associated with concomitant TBTB; however, the results of a multivariate analysis, indicated it was not a risk factor. However, the present study indicated that atelectasis was identified in 8.8% of TBTB cases, which was an independent predictor of TBTB and tracheobronchial stenosis. It was concluded that bronchial stenosis or occlusion caused by TBTB may be more likely to lead to lung atelectasis. Guo *et al* (34) demonstrated that the cavity lesion type exhibited the highest incidence among all types of TBTB lesion. Furthermore, they indicated that the cavity type was more likely to be associated with bronchial stenosis or obstruction (34). However, the present study did not assess the association between the cavity type and concomitant TBTB. The reason may be that the majority of the patients with cavitary TB enrolled had already received anti-TB treatment for a certain period of time and as a result, the release of MTB was not apparent.

The present study had several limitations. First, the number of drug-resistant TB patients among patients with TBTB was not analyzed. In addition, it was not assessed whether TBTB patients with drug resistance presented with a higher number of serious complications or a longer course of disease than drug-susceptible subjects. As another limitation, the follow-up information and lung function of the patients with TBTB were not recorded in the present study due to the long period and the high cost required for the follow-up. Furthermore, it is difficult to distinguish between dead and live mycobacteria by applying the GX method. Therefore, additional techniques, including AmpSure simultaneous amplification and a testing method for the detection of *Mycobacterium tuberculosis* should be considered in order to fully diagnose and manage the patients with TBTB. Finally, other potential risk factors, including profession, body mass index and living environment, were not analyzed in the present study.

The present study retrospectively assessed the incidence, laboratory diagnostic yields and the predictors of TBTB in Chongqing. The factors of female sex, atelectasis and cough were the major independent predictors of concomitant TBTB. Furthermore, cough and atelectasis were independent predictors of persistent tracheobronchial stenosis associated with TBTB. GX was more sensitive than sputum smears and bronchial brushing smears for the detection of patients with TBTB. Finally, it was concluded that the timely and appropriate diagnosis of patients with PTB suspected to have combined TBTB and the guidance of their respective treatment requires two or more laboratory techniques.

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Availability of data and materials

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

Authors' contributions

YC and AZP designed the current study. YC, AZP, QQ, SY and SJL generated data. AY extracted data from archives. YC and AY analyzed data. YC wrote the initial draft of the manuscript. YC and AY revised the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Ethical approval was obtained from the Public Health Medical Center Review Board (Chongqing, China). Permission to perform the current study was obtained from the Public Health Medical Center administration. Collected data were confidentially stored in a computer with access to authorized individuals only.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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