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Original Article

Efficacy of video-assisted thoracoscopic surgery for 29 patients with tuberculosis-destroyed lung

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Abstract: Background: Incompleteness of interlobar fissures and pleural adhesions, common in tuberculous destroyed lung (TDL), are among "technical contraindications" for video-assisted thoracoscopic surgery (VATS). The efficacy and safety of VATS in the treatment of TDL, has not yet been detailed in. Objective: The objective of the present study is to observe the efficacy and safety of VATS in the management of TDL. Methods: A retrospective review of anatomic lobectomy by VATS on 29 cases of TDL was performed in the Department of Thoracic Surgery of Wuhan Medical Treatment Center between October 2010 and October 2013. Results: All the 29 surgeries by VATS were successfully completed. No death case was reported. Operative duration of VATS was 75~400 min, with an average of 185.4 min; intraoperative amount of bleeding ranged 50 to 2300 ml, with an average of 575.6 ml; the incidence of postoperative complication was 21.4% (6/28). Postoperative complications occurred in 6 cases, among which there were 2 cases of persistent postoperative pulmonary air leak, 2 cases of pleural effusion, one case of thoracic hemorrhage and one case of arrhythmia complicated with left heart failure. There was one patient who was converted from VATS to open thoracic surgery half-way. Conclusion: Our results have shown the efficacy, safety and a breakthrough in the "technical contraindications" of VATS in the management of TDL.

Keywords: Video-assisted thoracoscopic surgery, anatomic lobectomy, tuberculous destroyed lung

Introduction

Thoracoscopic lobectomy for the treatment of pulmonary tuberculosis has been reported in a few studies previously [1-3], but incompleteness of interlobar fissures and pleural adhesions, common in tuberculous destroyed lung (TDL), are among "technical contraindications" for thoracoscopy [1, 4]. Anatomic lobectomies were performed on patients with TDL by the application of video-assisted thoracoscopic surgery (VATS), based on experience in a large amount of tuberculosis thoracic operations in Wuhan Medical Treatment Center during the period between October 2010 and October 2013. 29 VATS on patients with TDL were completed. We hope to break through the restricted area of VATS, through a clinical analysis of anatomic lobectomy by VATS on the 29 patients with TDL, and an exploration on the issues involved in tuberculosis destroyed lung, such as the indications of VATS, operation field exposure, and separation of the destroyed lung. In addition, our knowledge and experience in the treatment of TDL by VATS are presented in this article.

Materials and methods

Clinical data

29 patients with TDL, ranging in duration of disease from 3 to 24 years, with an average of 9.2 years, were included in the study. All patients underwent preoperative anti-tuberculosis therapy, regular or irregular. After destructive lesions of the lung occurred, medical therapy of recurrent or multiple regular anti-tuberculosis for 3 months to 6 years was invalid. Demographics (gender and age), duration of disease,

Table 1. Demographics, indications and locations of destroyed lung in patients who underwent VATS

Clinical features	Results
Demographics	
Gender	
Male (n)	20 (69.0%)
Female (n)	9 (31.0%)
Age (year)	
Range	20~65
Mean ± SD	45.1 ± 12.0
Duration of disease (year)	
Range	3~24
Mean ± SD	9.2 ± 5.4
Indications	
Bronchiectasis and hemoptysis	16 (55.2%)
Pulmonary aspergillosis	4 (13.8%)
Bronchial stenosis and pulmonary atelectasis	6 (20.7%)
Continuously positive smear	9 (31.0%)
Multi-drug resistance and continuously positive smear	6 (20.7%)
Tuberculous cavities	8 (27.6%)
Locations of destroyed lung (n)	
Right upper lobe	11 (31.9%)
Right upper and middle lobe	4 (13.8%)
Left lower lobe	4 (13.8%)
Left upper lobe	8 (27.6%)
Left lower lobe	2 (6.9%)
Left whole lung	1 (3.5%)

VATS, video-assisted thoracoscopic surgery.

indications of VATS and locations of destroyed lung in patients who underwent VATS are shown in **Table 1**. All the surgeries were done by Dr Huang or Dr Ni, both experienced in tuberculosis lung surgery, and all were assisted by Dr Zhou. The protocols in this study have been approved by the ethical review board of Wuhan Medical Treatment Center (Wuhan, China), and written informed consent was obtained from every participant.

Case selections and preoperative preparation

Diagnostic criteria: The definition of TDL in this study is destroyed lung due to sequelae from past tuberculosis. The diagnosis of TDL was based on a clear history of past tuberculosis with a finding of parenchymal destruction by tuberculosis verified by chest X-ray or CT scanning [4] (see **Figure 1**).

Inclusion criteria: The inclusion criteria were as follows: (1) patients whose TDL lesions involved more than one lobe; (2) patients with no history of asthma or COPD before tuberculosis; (3) patients with no active tuberculosis; (4) patients aged ≥18 years; (5) symptomatic patients who had failed medical treatment, continued to have productive cough, hemoptysis and failure to thrive [5].

Exclusion criteria: Exclusion criteria were as follows: (1) insufficient clinical information; (2) history of chest surgery or major abdominal surgery; (3) kyphoscoliosis or chest wall deformity/anomaly or (4) coexisting medical problems, such as ischemic heart disease, asthma, chronic obstructive pulmonary disease, idiopathic pulmonary fibrosis, and malignancy [6].

All the patients received regular anti-tuberculosis treatment and were considered as treatment failure according to the definition in WHO guidelines for treatment of tuberculosis (fourth edition), since their sputum smear or culture were positive at 5 months or later during treatment, or they were found to harbor a multidrug-resistant (MDR) strain [7]. Preoperative fiberoptic bronchoscopy confirmed no endobronchial tuberculosis in all cases; patients with negative sputum smears received standard anti-tuberculosis treatment for at least 6 months; patients with positive ones switched to second-line anti-tuberculosis treatment scheme (sodium aminosalicylate, amikacin, ethionamide and levofloxacin) for at least 3 months due to ineffective single chemotherapy; those with signs of pulmonary aspergillosis by imageology were preoperatively treated with itraconazole capsules or amphotericin B injection for at least one month.

Surgical techniques

The patients received general anesthesia with dual-lumen endotracheal intubation confirmed by fiber-optic bronchoscopy [8-12], and were placed in the contralateral decubitus position. 2 or 3 holes, i.e., 1 to 5 cm incisions were

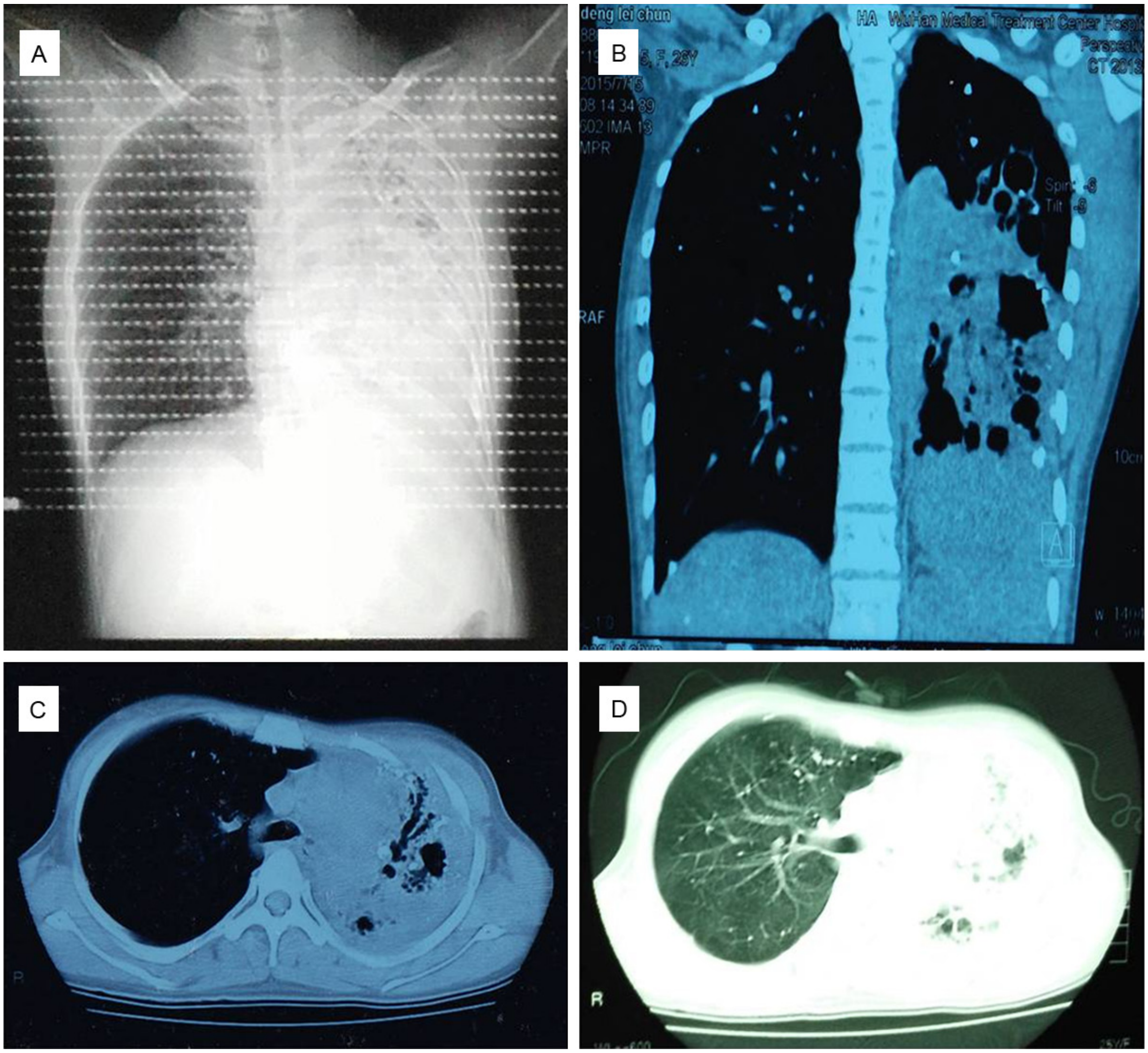

Figure 1. Data of chest X-ray or CT scanning. A: Chest radiography shows a collapse, cavities and some pleural thickening in left lung, and a focal fibrotic change in over-expanded right lung. B-D: Chest CT scan demonstrates dense masses, fibrotic cavities with volume loss and pleural thickening in left lung, with no normal lung structure identified, and hypervascularity and peribronchial lymph node calcification in right lung as well.

adopted in all the operations. A 1.0 cm incision as the thoracoscopic observation hole at the seventh or eighth intercostal space between the midaxillary line, and a second horizontal incision of 3 to 5 cm as the main operation hole at the third or fourth intercostal space depending on the circumstances, was made. It was determined according to intraoperative conditions, whether to adopt vice operation holes, mostly 2 cm, located in the subscapular angle line which was in the same intercostal space as the observation holes was in. Operations were carried out under complete thoracoscopy, with anatomic lobectomy as the surgical procedure. A unidirectional procedure was utilized in the majority of the operations. However, the specific decisions were based on intraoperative conditions. After observation holes were cut open in the seventh or eighth midaxillary line, a 3~5 cm incision was made as the main operation hole in the third or fourth anterior intercostal place. The anesthetist was instructed to implement unilateral pulmonary ventilation, to collapse the lung on the operative side, in order to facilitate the separation. Gauzes were clamped with fingers or oval clamps. A blunt separation or a sharp separation was conducted with an electric knife on the adhesions between lateral chest walls (see **Figure 2A** and Video 1). A tunnel was established between the

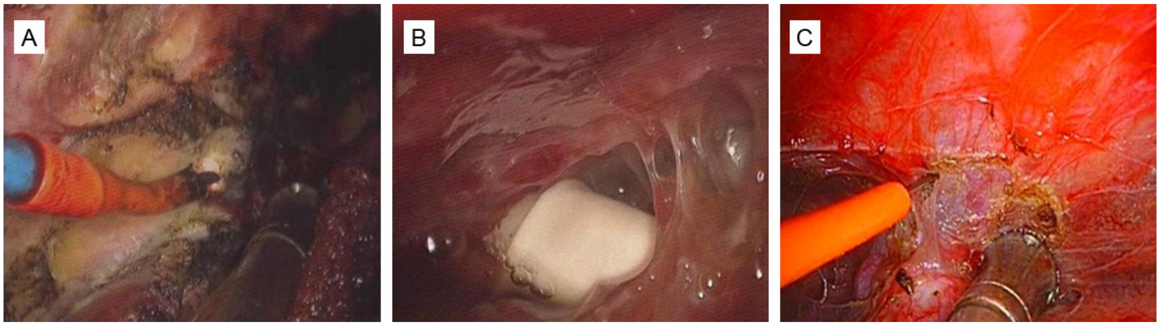

Figure 2. Key data of video-assisted thoracoscopic surgery. A: A blunt separation or a sharp separation was conducted with an electric knife on the adhesions between lateral chest walls. B: A tunnel was established between the observation hole and the operation hole. C: Dense callus-like adhesions were separated with an electric knife tip along sparse vascular area at adhesion site to avoid an injury to thoracic vessels and lung tissues.

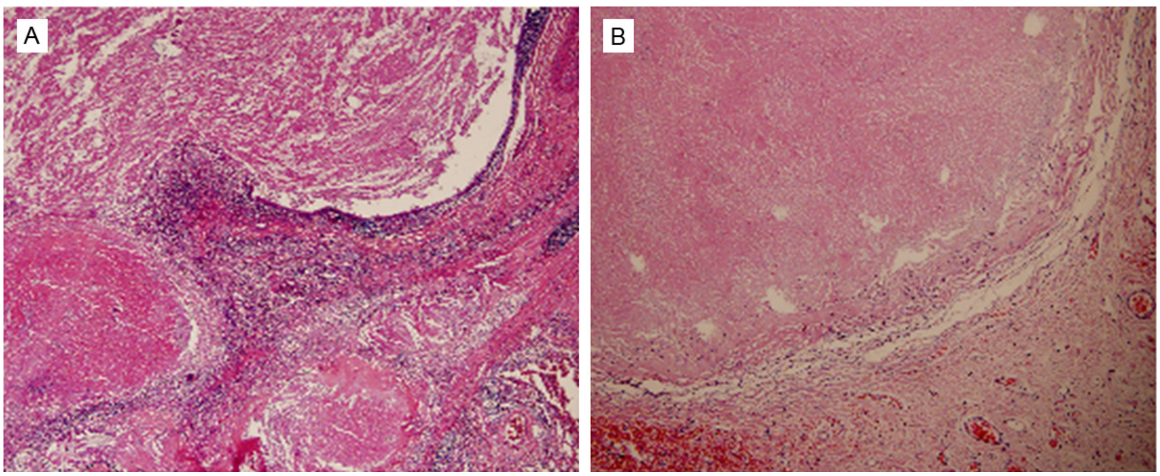

Figure 3. H&E staining of slice from a certain patient with tuberculous destroyed lung displays multiple nodular lesion, cheese necrosis located in the middle, and hyperplasia of fibrous connective tissue and calcification in the periphery of which. Besides, concomitant bronchial dilatation was presented (Original magnification × 100).

observation hole and the operation hole, and then the adhesions were progressively separated through the tunnel under thoracoscope (see **Figure 2B** and Video 2). Dense callus-like adhesions were separated with an electric knife tip along sparse vascular area at adhesion site to avoid an injury to thoracic vessels and lung tissues (see **Figure 2C** and Video 3). Afterwards, hilar and fissures were sharp dissected successively, and incomplete lobar fissures were incised and sutured after the tunnel was opened up. Pulmonary artery, pulmonary vein and individual branches were exposed and handled with vascular cutting and stapling device respectively, and adjacent branches were incised and sutured together. Finally, bronchi were disarticulated, and lung resection was complete. After a complete hemostasis within the surgical field, thoracic cavity was repeatedly flushed with warm saline. Thoracic cavity in which one or two drainage tubes were placed (a thoracic drainage tube was placed in patients with lower lobectomy through an observation hole, and an additional drainage tube was inserted through the operation hole, till up to the top of the thoracic cavity to facilitate drainage as for the patients with middle or upper lobectomy) was closed, after it was confirmed by check up all the instruments and dressings in operations.

Statistics

Variables such as age, duration of disease, operative duration, blood loss, postoperative chest drainage duration and postoperative hospital stay, are expressed and analyzed as mean ± SD, while for follow-up period, due to its non-

Table 2. Operative duration, blood loss, postoperative chest drainage duration, postoperative hospital stay, and sputum smear from patients who underwent VATS

Item	Results
Number of successful operation, n	29
Number of death case, n	0
Operative duration (Mean ± SD, minute)	
Range	75~400
Mean ± SD	185.4 ± 107.2
Blood loss, mL (Mean ± SD)	
Range	50~2300
Mean ± SD	575.6 ± 513.3
Postoperative chest drainage duration, d	
Range	4~18
Mean ± SD	7 ± 2.8
Postoperative hospital stay, days (Mean ± SD)	
Range	6~55
Mean ± SD	14 ± 9.5
Positive smear after operation, n	0

Table 3. Postoperative complications in patients who underwent VAT

Postoperative complications	Results (percentage in 29 patients)
Persistent pulmonary air leak	2 (6.9%)
Pleural effusion	2 (6.9%)
Thoracic hemorrhage	1 (3.5%)
Arrhythmia with left heart failure	1 (3.5%)
Total, n	6 (20.7%)

normal distribution, median is calculated instead. All data are analyzed by use of the SPSS 13.0 statistical software package.

Results

All the operations were successfully completed. All cases were definitely diagnosed as pulmonary tuberculosis by postoperative pathology (see **Figure 3**). No death case was reported. The results concerning operative duration, blood loss, postoperative chest drainage duration, postoperative hospital stay, and sputum smear are displayed in **Table 2**. Postoperative complications occurred in 6 cases, among which there were 2 cases of persistent postoperative pulmonary air leak who were fully recovered by continuous suction drainage, 2 cases of pleural effusion, including one cured by repeated thoracentesis and another restored to health by closed thoracic drainage, one case of thoracic hemorrhage resulted from an adhesive band in thoracic cavity who had a second thoracoscopic surgery and succeeded in electric coagulation, and as well as one case of arrhythmia complicated with left heart failure who improved conditions and was discharged after medications (**Table 3**). There was one patients who was converted from VATS to open thoracic surgery due to pleural atresia resulted from lung destroy. All the 29 patients (100%) have been followed up at 3 months, 28 (96.6%), 25 (86.2%), 15 (51.7%), 10 (34.5%) at 6, 12, 24 and 48 months, respectively. Median follow-up period was 30 months (range 3 to 48 months). Chest roentgenogram and sputum bacteriological investigations were conducted in follow-up.

Discussion

With the advent of VATS, the use of this approach for diagnosis and treatment of tuberculosis was realized [13]. Thoracoscopy has been widely recognized for its efficacy in early stage lung tumors [14]. However, as regards to its effect in the treatment of pulmonary tuberculosis, in particular, of TDL, has not yet been detailed in. Tuberculosis may come across a few new problems in its treatment when VATS is executed. Pleural thickening or adhesion, fissural adhesion, cavity and peribronchial lymph node calcification are typical in TDL. Adhesion, or even atresia of thoracic cavity resulted from chronic inflammation, is the worst obstacle to VATS offered to the patients with TDL, and furthermore, was once considered a contraindication for thoracoscopic surgery [1, 15]. In a study of the treatment by VATS lobectomy for lung cancer, Vadim G. Pischik [16] made an attempt at extending the indications to VATS lobectomy, and held that incompleteness of interlobar fissures and pleural adhesions are not supposed to be the contraindications for VATS.

Facts have proved that there are still some patients with TDL who can still undergo VATS. Moreover, the efficacy and safety of the operations have turned out to be affirmative. The separation of local adhesion or widely loose adhesion under thoracoscope, may have an advantage over that through open thoracic surgery, in that thoracoscopy has an amplifying action and a deep illumination effect, consequently, some adhesion of chest top and diaphragmatic surface can be displayed more clearly.

Duration of operation, amount of bleeding or incidence of postoperative complication each serves as a criterion for evaluation of minimally invasive surgery. Duration of conventional open thoracic surgery for TDL reported previously is 354 min [17], or 216 ± 78 min [18]; intraoperative average amount of bleeding ranges is 1046 ml [17], or 1240.0 ± 1122.5 ml [18]; the incidence of postoperative complication is 18.6% (32/172) [18]. As observed in the present study, duration of VATS for TDL is 75~400 min, with an average of 185.4 min, intraoperative amount of bleeding ranges 50 to 2300 ml, with an average age of 575.6 ml, and the incidence of postoperative complication is 21.4% (6/28). It suggests that there remains a superiority of VATS in a portion of patients with TDL.

We have successfully used VATS in the treatment of TDL and our experience forms the basis of this article.

Above all, thickening or even tortuosity of the bronchial artery is frequently discovered during an operation in the hilar region of the patients with long-term tuberculosis or secondary bronchiectasis, consequently, ligature or suture is ordinarily necessary for homeostasis. Incisions as vice operation holes can be omitted over the patients without adhesion, but as for the patients with adhesion, vice operation hole is still of great significance; as for the patients with extensive membranous adhesions, a small incision in the chest wall is required to be made as an operation hole at the operation site or in the hilar region. After the thoracic cavity is entered, the field of view under the thoracoscope is flushed, so as to expand the operating space, then the adhesions are carefully dissociated. In such a case, separations ought to be performed in accordance with the principles of “from the easy and shallow to the profound and deep”, since they tend to be extremely difficult owing to a wide range of adhesions. Dense callus-like adhesions are separated with an electric knife tip along sparse vascular area at adhesion site to avoid an injury to thoracic vessels and lung tissues. Since a partial or complete fissure fusion generally develops in patients with TDL, a unidirectionally progressive resection is commonly employed. Vessels and bronchi are first processed, then is fissure; the procedure can also be that, first, artificial lung fissure is manufactured and all the vessels and bronchi are exposed, then, lobectomy is conducted. Severe adhesions on the diaphragmatic surface that are difficult to be dissociated through the operation holes, can be dissociated through observation holes.

Besides, the specific criterion will be well grasped by the clinical experience of expert doctors. It is greatly possible that bronchopleural fistula occurs in the cases of smear-positive pulmonary tuberculosis, drug-resistant pulmonary tuberculosis, or pulmonary fungal disease, so the operation should be emphasized on the prevention of fistula. The view is shared among a lot of scholars that reinforcements on bronchial stump should be effective in preventing the development of fistula [19]. There remains a controversy with regard to whether or not stump is embedded with an autologous tissue or artificial materials after operation. It is proposed by some scholars that the stump be embedded with materials such as intercostal muscles, pleural slice or pericardiac fat pad [20-22], or also reported that that be done with allogeneic or artificial materials. There are still others who hold that the stump does not have to be embedded and that it can be automatically covered by peribronchial lymph nodes and soft tissues postoperatively [1, 23]. The stump was not handled for embedding in the patients enrolled in our study.

Moreover, persistent postoperative pulmonary air leak is one of the most common complications involved in patients with TDL after operation. Persistent pulmonary air leak occurred in 4 patients in the present study. It can be remarkably reduced or relieved as the wound of the remaining lung is sutured with 5-0 prolene sutures under thoracoscopy. However, the suture of multiple pulmonary lacerations can lead to reduced lung capacity and decreased pulmonary reexpansion ability, so we advocate no treatment for the pulmonary air leak with a small crevasse but a pleurodesis at the end of the operation; but as regards to the pulmonary air leak with a large crevasse, it is necessary that the wound of the remaining lung be sutured with 5-0 prolene sutures.

In addition, effective anti-tuberculosis and anti-aspergillus therapy both before and after operation are the crucial factors for the prevention of bronchopleural fistula. Postoperative anti-aspergillus therapy is an important guarantee for wound healing, and prevention of its recurrence. As for those patients with pulmonary aspergillosis, anti-aspergillus agents should be used preoperatively for at least one month. The entire lobes are completely resected as far as possible during operation. A sufficient postoperative drainage is a requisite, and the drainage fluid is submitted for inspection when necessary. It is noteworthy that not only is anti-aspergillus therapy applied preoperatively, but also the integrity of lung tissue should be maintained intraoperatively as far as possible, so as to avoid ruptured pulmonary cavities and thoracic contamination, which can result in pleural empyema postoperatively. For that reason, at the end of operation on the cases with TDL, thoracic cavity is repeatedly flushed with as much as 3000~5000 ml of warm saline, and besides, anti-tuberculosis or anti-aspergillus therapy is timely utilized after operation. Preoperative and postoperative anti-tuberculosis treatment is likewise the key to a successful treatment of TDL by VATS especially for those with drug-resistant tuberculosis [21]. Numerous thoracic surgeons usually neglect anti-tuberculosis therapy before surgical treatment of tuberculosis, but the experience acquired with this study supports the necessity of an effective anti-tuberculosis treatment for at least 2~3 months to conduct a surgical treatment. The reason lies in the fact that, for one thing, it reduces systemic dissemination of tuberculosis intraoperatively and postoperatively, for another, it rules out those patients with drug-resistant pulmonary tuberculosis. A combined, regular, appropriate and full course treatment of anti-tuberculosis after operation should be offered as well.

Previous studies reported that unsafe feelings of the surgeon [16], dense adhesion in the pleural space or around hilar structures, peribronchial lymph node calcification, and bleeding due to bronchoectasis, or severe perivascular fibrosis and/or calcification, were highly indicative of conversion to a conventional thoracotomy or an auxiliary operation with small incisions [15]. The present study demonstrated that there was only one patient (3.45%) who was converted to open thoracic surgery for pleural atresia resulted from lung destroy. As Weber et al. [5] have claimed, "we converted at times to an open procedure just for safety reasons. It depends very much on the wound and quality of adhesions during surgery. We consider this not as a failure rather than a safety measure".

Although this is the first case series of VATS for the treatment of TDL to date, it has some limitations. Above all, it is retrospective and not randomized. Then, inclusion criteria for this procedure are unclear at present [24]. We believe that VATS for TDL, although technically feasible, should still be regarded as experimental [24]. After all, the follow-up period is relatively short. Therefore, the role of VATS in the treatment of TDL can only be defined by prospective trials compared with the conventional approach with long-term follow-up [24]. Although having these limitations, our result has shown the efficacy and safety of VATS in the management of TDL. Massive challenges remain for the application of thoracoscope to such surgeries as pneumonectomy and thoracoplasty [1].

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Disclosure of conflict of interest

None.

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