

# Clinical research of treating tuberculous respiratory failure by sequential mechanical ventilation

Chengqun Ge, Tao Zhang and Houcui Fan\*

Linyi People's Hospital, Linyi, China

**Abstract:** Tuberculosis is kind of common chronic infectious disease, of which the pathogenic bacterium is mainly Mycobacterium tuberculosis (MTB). One who is suffering severe tuberculosis may be ended with cardio-pulmonary function damage or cardio-pulmonary failure. This disease is of higher risks of complications or even high death rate, which is seriously challenging people's health and life. When a tuberculosis patient is accompanied with respiratory failure, which means the disease has developed into the late stage, on this occasion the optimal treatment program is to use mechanical ventilation to improve the respiratory failure condition. This research mainly explored the clinical effect of treatment of tuberculous respiratory failure by sequential mechanical ventilation, and observed clinical treatment effect, patients' basic conditions, condition of VAP and deterioration-in-death condition after sequential mechanical ventilation.

**Keywords:** Tuberculosis, respiratory failure, sequential mechanical ventilation, clinical effect.

## INTRODUCTION

Tuberculosis is clinical a kind of infectious disease caused MTB. This disease can infect many human organs, wherein the most common one is the pulmonary tuberculosis. Many excreters are the major infection sources of such disease. After being infected by tubercle bacillus, people may not always feel the attack of this disease, only when cellular immunity decreases or cell-mediated allergy increases, will the significant clinical symptoms emerge (Li 2013; Ahmad *et al.*, 2016; Tseng and Tuszyński 2015). Respiratory failure refers to a severe dysfunctional disease of human respiratory system, of which the pathogenesis is that the air breathed causes gas exchange impairment in alveolar, making CO<sub>2</sub> amount larger than that of O<sub>2</sub> (i.e. lack of O<sub>2</sub>), and eventually resulting in body metabolic disorder (Fu *et al.*, 2013; Liu and Liu 2010; Peng *et al.*, 2012). Severe pulmonary tuberculosis may cause respiratory failure, on this occasion, mechanical ventilation is a preferred method that can effectively treat the symptoms of respiratory failure (Zhang 2015; He and Liu 2013). This paper mainly researched the clinical effect and safety of treating tuberculous respiratory failure by sequential mechanical ventilation.

## MATERIALS AND METHODS

In clinical practice, pulmonary tuberculosis is the most common tuberculosis with incident rate of 160/100000 and totally 2 million patients in current China. According to the different body responses to first and second infection of tubercle bacillus, pulmonary tuberculosis display different disease development characteristics

(Zhang 2015; Selim *et al.*, 2016; Oliveira *et al.*, 2016) (fig. 1). Radiographic images of pulmonary tuberculosis are shown in figs. 2 and 3.

Primary tuberculosis is different from secondary tuberculosis, wherein the former one refers to the first-time infection of mycobacterium tuberculosis, while the later one refers to the secondary infection which is normally exists in adults. Most patients of primary tuberculosis will show syndromes in short period, which is normally from 10 years to decades, with a significantly decrease of immunity (Sun *et al.*, 2014; Khalifa *et al.*, 2016; Miao *et al.*, 2016; Selim *et al.*, 2016). While the secondary tuberculosis can be categorized into different types shown in fig. 4.

Apart from the difference of infection time between primary tuberculosis and secondary tuberculosis, there are other differences as well, which are specifically shown in table 1.

In clinical practice, mechanical ventilation is normally employed to treat tuberculous respiratory failure, however it takes long time and suffers higher probability of VAP and disease progression, causing repeated treatment process and increasing medical cost and case fatality rate. In recent years, sequential mechanical ventilation has been adopted to decrease the incident rate of VAP, improve patients' respiratory function. In this research, 30 patients of tuberculous respiratory failure are all treated with sequential mechanical ventilation, wherein the treatment process using sequential mechanical ventilation is shown as fig. 5.

After being hospitalized, a confirmed diagnosis should be given. Under the premise of confirming tuberculous respiratory failure, conventional treatment of mechanical

\*Corresponding author: e-mail: houcuifan2016@163.com

**Table 1:** Comparison between primary tuberculosis and secondary tuberculosis

Differences	Primary tuberculosis	Secondary tuberculosis
Infection time	First time infection	Secondary infection
Pathological characteristics	Primary complex	Various but relatively limited lesions, coexistence of old and new lesions
Lesion nature	Exudation and necrosis	The formation of lymphogranuloma venereum and necrosis
Specific immunity and allergy	No specific immunity, with occurrence of allergy	Specific immunity, Lesions localized
Location of initial lesion	Lower part of lobus superior pulmonis and upper part of lobus inferior pulmonis	Apex of lung
Diffusion approach	Lymphatic channel and blood channel	Bronchus

**Table 2:** Comparison of improvement condition of clinical indexes

Time	BR(cycle/min)	HR(cycle/min)	PaCO <sub>2</sub> (mmHg)	PaCO <sub>2</sub> (mmHg)	PH
Before extubation	16±5	89±11	45±12	83±9	7.37±0.05
After extubation	24±6	96±9	46±14	81±11	7.36±0.02

**Table 3:** Duration of ventilation, VAP incident rate, condition of deterioration and death

Case	total duration of mechanical ventilation (d)	VAP incident rate (%)	Rate of deterioration and death (%)
30	11.9±7.6	6.67	3.33

ventilation including anti-infection therapy, anti-tuberculous therapy, removing phlegm and spasm relieving treatment should first be given. Secondly, implement treatment according to related application principles of invasive mechanical ventilation (Zhang *et al.*, 2015; Shi *et al.*, 2016; Liu, 2013; Ashrafuzzaman, 2015). In addition, adjust respirator's fraction of inspired oxygen (FiO<sub>2</sub>) according to patient's condition, blood gas analysis result, ventilation condition and patient's tolerance degree and synchronize respirator's parameters such as SIMV respiratory rate, tidal volume, PEEP and PS level. After patient's condition and ventilatory function recovers a little, gradually decrease PS level till to 10~12cmH<sub>2</sub>O and SIMV frequency down to 10~12 cycle/min. On the other hand, what is worth noting is that conventional treatment such as anti-infection and anti-tuberculous treatment, nutritional support and sputum drainages should be still given while conducting mechanical ventilation.

Carefully observe change condition of patient's various vital signs during mechanical ventilation. When the lung infection shadow shows following changes including phlegm being significantly absorbed, significant decrease of patient's temperature, numeration of leukocyte in blood sample being less than 10\*10<sup>9</sup>/L or decreased by 2 unit as compared with that before treatment, sputum being significant decreased in quantity, gradually turning white or becoming shallow, and decreased by 2 unit in viscosity, it can be concluded that pulmonary infection controlled

(PIC) window is emerged in the treatment (Shen 2014; Mahmood and Aldahmash, 2015; Zhang *et al.*, 2016).

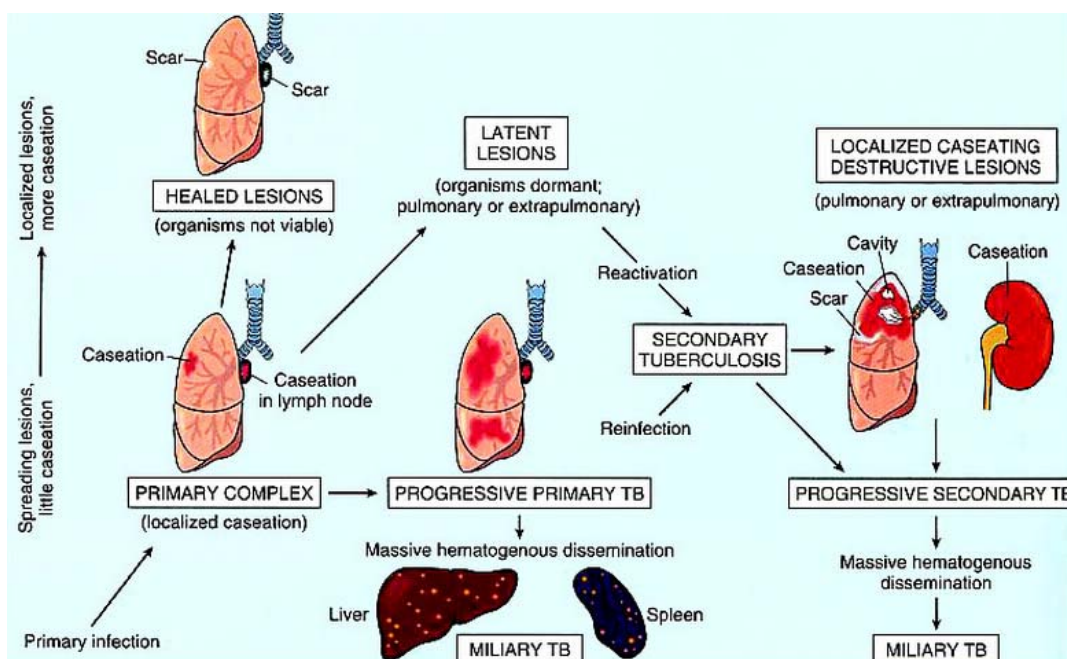
When PIC window appears, remove tracheal intubation, change non-invasive positive pressure ventilation, and adjust parameters such as FiO<sub>2</sub>, PS, PEEP according to patient's respiratory condition. The optimal parameters should be respiratory rate less than 30 cycle/min, arterial blood CO<sub>2</sub> partial pressure (PaCO<sub>2</sub>) controlled within 40~60mmHg, and arterial blood O<sub>2</sub> partial pressure (PaO<sub>2</sub>) controlled within 60~90mmHg. When patient recover little by little, successively decrease PEEP level, PS level, and duration of ventilation, and remove ventilator when patient recovers autonomous respiration (Wang *et al.*, 2014).

After finishing the treatment, record patient's basic conditions in 24h after switching to noninvasive positive pressure ventilation therapy, wherein indexes needed to be observed are shown in fig. 6. In addition, record the total duration of mechanical ventilation, VAP incident rate, and the probability of exacerbation and death.

## RESULTS

### *Basic condition of patient's clinical indexes*

In this research, 30000 patients are applied with sequential mechanical ventilation treatment, and it can be found that all patients' clinical syndromes are significantly improved after treatment, and there is statistical



**Fig. 1:** Development course of pulmonary tuberculosis.

significance between parameters before extubation and that after extubation (table 2).

#### ***Duration of ventilation, VAP incident rate, condition of deterioration and death***

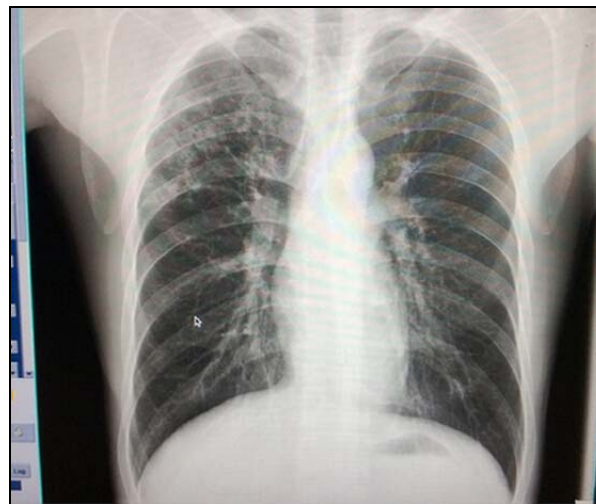
After applying sequential mechanical ventilation treatment for 30000 patients, indexes such as duration of ventilation, VAP incident rate, condition of deterioration and death are shown in table 3.

## **DISCUSSION**

Pulmonary tuberculosis is a chronic infectious disease. One who is with severe pulmonary tuberculosis will suffer twisted airway, different degrees of lung tissues damages, and abnormal anatomical structure of airway. In addition, TB patient may suffer secondary symptoms such as spasm, airway inflammation and alveoli exudation. In clinical practice, patient with tuberculous respiratory failure normally suffers the coexistence of tuberculosis sequelae, severe pulmonary tuberculosis and other chronic obstructive pulmonary disease, on this basis, it is suggested to implement invasive mechanical ventilation treatment under the premise of securing patient's life, so as to relieve the symptoms of respiratory failure and ease the fatigue of respiratory muscle (Yan *et al.*, 2014).

Since TB patient suffers low condition of body immune function for long as well as the malnutrition which probably cause respiratory muscle fatigue, if being in ventilation treatment for long, patient will get used to the machine ventilation, likely leading to disuse atrophy of respiratory muscle and keeping independent ventilation

consciousness of patient in pathological state for long, which is not helpful for the recovery.



**Fig. 2:** Radiographic image of pulmonary tuberculosis

In this research, the applied sequential mechanical ventilation method is to build invasive mechanical ventilation mainly based on artificial airway, after patient's condition being controlled, the non-invasive positive pressure ventilation will be used instead, which can decrease the occurrence rate of complications as well as hospitalization expenses. Firstly, the invasive mechanical ventilation is established using artificial airway, which can enhance drainage of sputum, improve breathing condition, so as to control infection and slow release respiratory failure condition. However, long-term invasive mechanical ventilation easily results in VAP,

therefore, invasive mechanical ventilation is of certain defects. On this basis, noninvasive positive pressure ventilation therapy can be switched on under the premise of guaranteeing ventilation effect, so as to taking the advantages of both invasive and noninvasive ventilation method. In the early stage of mechanical ventilation, invasive mechanical ventilation is implemented through building artificial airway can improve breathing and discharge sputum, winning time for the implementation of noninvasive positive pressure ventilation after infection being controlled. Such treatment sequence can effectively reduce the incident rate of VAP and related complications (Bai, 2014; Lv et al., 2016; Sun et al., 2016; Shaman and Kowalski, 2016).



Fig. 3: Radiographic image of pulmonary tuberculosis

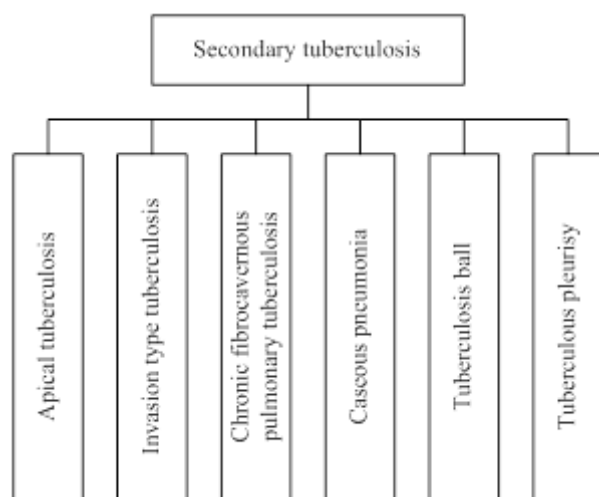


Fig. 4: Classification of secondary tuberculosis

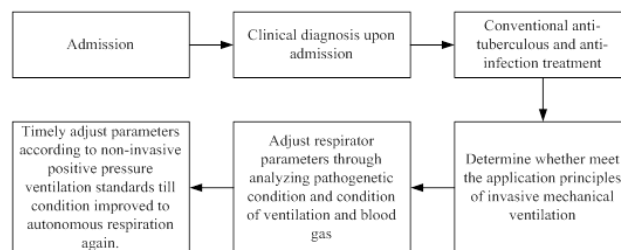


Fig. 5: Treatment process of non-invasive sequential mechanical ventilation

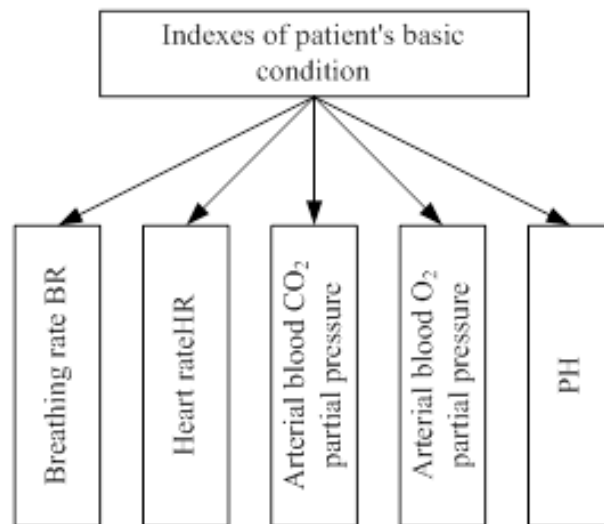


Fig. 6: Observed disease indexes within 24h after removing tracheal intubation and implementing non-invasive positive pressure ventilation

The research results show that in the process of treating tuberculous respiratory failure using sequential mechanical ventilation, the duration of invasive ventilation is significantly reduced, the probability of VAP is significantly decreased also, and the pain of re-intubation and medical cost are reduce thereby. Therefore, it can conclude that the sequential mechanical ventilation treatment is a safe and effective method, which is of higher clinical application value.

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