Am J Transl Res 2021;13(7):8409-8414
www.ajtr.org /ISSN:1943-8141/AJTR0132051

Original Article

Application of sputum suction by fiberoptic bronchoscope in patients with severe pneumonia and its effect on inflammatory factors

Binbin Li[1], Zhihai Li[2], Wu Cheng[1], Baoyi Zhang[4], Wengui Zhu[1], Zhongtie Lin[3]

Departments of [1]Respiratory, [2]General Practice, [3]Infectious Diseases, Yongjia People's Hospital, Wenzhou, Zhejiang Province, China; [4]Department of Respiratory, Wenzhou Central Hospital, Wenzhou, Zhejiang Province, China

Received February 19, 2021; Accepted March 28, 2021; Epub July 15, 2021; Published July 30, 2021

Abstract: Objective: To evaluate the application of sputum suction by fiberoptic bronchoscope to patients with severe pneumonia and its effect on inflammatory factors. Methods: One hundred and three patients with severe pneumonia were randomly divided into the control group (n=52) and the observation group (n=51). Both groups were given anti-infection, antitussive and expectoration treatment. The observation group was treated with sputum suction by fiberoptic bronchoscope. The control group was treated with a vibration sputum extractor. The clinical efficacy, clinically related indexes, inflammatory factors, blood gas indexes and the Acute Physiology and Chronic Health Evaluation (APACHE II) score of the two groups were compared. Results: After the treatment, the total effective rate of the observation group was higher than that of the control group; the length of stay in ICU, mechanical ventilation time and duration of antibiotics of the observation group were shorter than those of the control group (all $P<0.05$). After the treatment, the serum levels of CRP, TNF-α and PCT and APACHE II scores in the two groups were all decreased, while PaO_2, SaO_2 and OI were increased; the changes in the observation group were more significant than the control group (all $P<0.05$). Conclusion: Sputum suction and lavage by fiberoptic bronchoscope can significantly control the body's inflammatory reaction state in patients with severe pneumonia, improve their blood oxygen and promote the treatment effect.

Keywords: Severe pneumonia, fiberoptic bronchoscope, inflammatory factor, blood gas

Introduction

Severe pneumonia, a respiratory infectious disease, is difficult to treat clinically. The disease progresses very fast, and the mortality rate is high, especially for elderly patients. They are often accompanied by other basic diseases, which increase the difficulty of treatment [1, 2]. Patients with severe pneumonia have a large amount of sputum in their respiratory tract, mostly viscous, and patients often find it not easy to cough out the sputum. Once the viscous sputum blocks the airway, patients may have obvious dyspnea and dysfunction of pulmonary ventilation and gas exchange. In severe cases, it can even cause death due to respiratory failure [3, 4]. Therefore, timely discharge of sputum is vital to improve the clinical symptoms, such as dyspnea, so as to improve the prognosis of patients with severe pneumonia.

Vibration expectoration is a conventional expectoration measure. Although it can promote partial sputum excretion, its effect is limited [5]. In contrast, sputum suction by fiberoptic bronchoscope can effectively promote the discharge of airway secretions in patients with severe pneumonia, help keep the patient's respiratory tract unobstructed and reduce the symptoms of dyspnea [6].

Dhungana et al. showed that sputum suction by fiberoptic bronchoscope could effectively shorten the mechanical ventilation time and the duration of antibiotics in patients with severe pneumonia and improve patients' pulmonary function [7]. However, research about the impact of different sputum suction methods on patients' blood gas and inflammatory state is rare. The goal of this study is to investigate the effect of sputum suction by fiberoptic broncho-

scope in patients with severe pneumonia and to analyze its effect on serum inflammatory factors and blood gas. The results of this study are reported as follows.

Materials and methods

Baseline information

In this prospective study, 103 patients with severe pneumonia in our hospital from September 2018 to February 2020 were divided into the control group (n=52) and the observation group (n=51) according to the method of random number. On the basis of drug therapy, a vibration sputum extractor was used in the control group to promote expectoration, and a fiberoptic bronchoscope was used in the observation group for sputum suction.

The inclusion criteria were: patients aged from 25 to 70 years old; patients who met the diagnostic criteria for severe pneumonia in the Diagnosis and Treatment of Community-Acquired Pneumonia in Adults (2016 clinical practice guidelines by the Chinese Thoracic Society, Chinese Medical Association) and were diagnosed with severe pneumonia by clinical examinations [8]; patients whose chest CT showed patchy and cloudy shadows in both lungs; patients with large amounts of purulent secretions in lungs. The exclusion criteria were: patients who could not tolerate bronchoscopy treatment; patients with insufficiency or failure of heart, liver, kidney and other organs; patients with mental illness; pregnant or breastfeeding women; patients allergic to the drugs used in the study. All patients signed an informed consent. This study was approved by the Ethics Committee of our hospital.

Methods

Both groups were given treatment such as anti-infection, relieving cough and expelling phlegm, maintaining fluid and electrolyte balance and mechanical ventilation for 12 to 14 consecutive days. Patients in the control group were given treatment with a vibration sputum extractor (Anhui Feinaer Technology Co., Ltd.; model: FPT-Q1500; place of origin: China) to promote the expectoration, twice a day. Patients in the observation group were given treatment with a fiberoptic bronchoscope for sputum suction [9]. Midazolam (Jiangsu Jiuxu Pharmaceutical Co. Ltd.; specification: 3 mL, 15 mg; place of origin: China) was injected intravenously for sedation. The trachea cannula was cut open, and the fiberoptic bronchoscope (Shanghai Sanwei Medical Equipment Co., Ltd.; model: ABF-5; place of origin: China) was inserted slowly into the cannula. 2% lidocaine (Yabao Pharmaceutical Group Co., Ltd.; specification: 5 mL, 86.5 mg of lidocaine; place of origin: China) was injected for local anesthesia. Airway secretions were suctioned under negative pressure. 0.9% sodium chloride solution at 37°C was used to lavage the lesions in the lungs, 10 mL per time, repeating the lavage until the suctioned fluid was clear, once every three days. Blood oxygen saturation (SpO_2) was closely observed during the sputum suction and lavage by fiberoptic bronchoscope. If the SpO_2 was less than 85%, the operation was stopped immediately.

Outcome measures

Primary outcome measures: The clinical efficacy after the treatment was appraised according to the Diagnosis and Treatment of Community-Acquired Pneumonia in Adults (2016 clinical practice guidelines by the Chinese Thoracic Society, Chinese Medical Association) [8]. Significantly effective: dyspnea and other symptoms completely disappeared or significantly improved; chest CT showed that inflammation disappeared. Effective: symptoms improved partially; chest CT showed that the scope of inflammation significantly reduced. Ineffective: the patient's condition did not meet the above standard. Total effective rate (%) = (significantly effective cases + effective cases)/total cases * 100.

The clinically related indexes, such as the length of stay in ICU, mechanical ventilation time and duration of antibiotics, were compared between the two groups.

Five milliliters of venous blood were extracted before and after the treatment, and the serum was separated by centrifugation. The serum levels of tumor necrosis factor-α (TNF-α), C-reactive protein (CRP) and procalcitonin (PCT) were detected by ELISA.

Secondary outcome measures: Before and after the treatment, 3 mL of radial or femoral artery blood were extracted from the patients.

Table 1. Comparison of baseline information between the two groups (n, $\bar{x}\pm sd$)

	Observation group (n=51)	Control group (n=52)	χ^2/t	P
Gender (n)			0.782	0.377
Male	27	23		
Female	24	29		
Age (year)	48.7±5.4	47.9±6.2	0.699	0.486
BMI (kg/m^2)	22.20±2.27	22.54±2.40	0.739	0.462
Complication (n)			0.796	0.672
Hypertension	8	11		
Hyperlipidemia	2	4		
Diabetes	4	3		

Note: BMI: body mass index.

The arterial partial pressure of oxygen (PaO_2) and saturation of oxygen (SaO_2) were detected by a blood gas analyzer (Shanghai Huanxi Medical Instrument Co., Ltd.; model: RAPIDPOINT 500; place of origin: China). Oxygenation index (OI) = PaO_2/FiO_2. FiO_2: the fraction of inspired oxygen.

The Acute Physiology and Chronic Health Evaluation (APACHE II) scores before and after the treatment were compared between the two groups, including acute physiology score (APS, 60 points), age (6 points) and chronic health status (CPS, 5 points) [10]. The total score was 71 points. Higher scores corresponded to a worse prognosis.

Statistical methods

SPSS 20.0 software was exploited to analyze the data. The count data were exhibited as n (%) and analyzed by the chi-square test. The paired-sample t-test was exploited to compare the data before and after the treatment. The independent-sample t-test was exploited to compare the data between the two groups. P<0.05 was reckoned significantly different.

Results

Baseline information

No significant difference was found in baseline information between the observation group and the control group (P>0.05). See **Table 1**.

Clinical efficacy

After the treatment, the total effective rate of the observation group was higher than that of the control group (P<0.05). See **Table 2**.

Clinically related indexes

The length of stay in ICU, mechanical ventilation time and duration of antibiotics in the observation group were shorter than the control group (all P<0.05). See **Table 3**.

Inflammatory factors

Before the treatment, there was no significant difference in the levels of serum CRP, TNF-α and PCT between the two groups (all P>0.05). After the treatment, the serum levels of CRP, TNF-α and PCT in the two groups were decreased, and those in the observation group were lower than the control group (all P<0.05). See **Table 4**.

Blood gas indexes

Before the treatment, no significant difference in PaO_2, SaO_2 and OI was found between the two groups (all P>0.05). After the treatment, PaO_2, SaO_2 and OI in the two groups all increased, and those of the observation group were higher than the control group (all P<0.05). See **Table 5**.

APACHE II scores

Before the treatment, the APACHE II scores of the observation group and the control group were 25.38±4.03 and 25.75±4.85, respectively. After the treatment, the APACHE II scores of the observation group and the control group were 13.36±3.27 and 16.64±3.55, respectively. Before the treatment, no significant difference was observed in the APACHE II scores between the two groups (P>0.05). The APACHE II scores in the two groups were decreased after the treatment, and those of the observation group were lower than those of the control group (all P<0.05). See **Figure 1**.

Discussion

Cough, phlegm and dyspnea are common clinical symptoms of severe pneumonia. If not treated in time, it can lead to systemic inflammation. In severe cases, it can even induce multiple organ failures and cause death [11]. Mechanical ventilation and endotracheal intuba-

Table 2. Comparison of clinical efficacy between the two groups (n, %)

Group	Significantly effective	Effective	Ineffective	Total effective rate
Observation group (n=51)	18 (35.29)	30 (58.82)	3 (5.88)	48 (94.12)[b]
Control group (n=52)	12 (23.08)	29 (55.77)	11 (21.15)	41 (78.85)

Note: Compared with the control group, [b]P<0.05.

Table 3. Comparison of clinically related indexes between the two groups (day, $\bar{x}\pm sd$)

Group	Length of stay in ICU	Mechanical ventilation time	Duration of antibiotics
Observation group (n=51)	10.84±2.20[b]	8.77±2.05[b]	7.03±2.14[b]
Control group (n=52)	13.37±3.17	11.28±2.64	9.20±2.01

Note: Compared with the control group, [b]P<0.05.

tion are the treatment measures to maintain the vital signs of patients and save their lives, which can save time for fighting infection. However, a large amount of viscous sputum in the respiratory tract seriously affects the lungs' ventilation function. If the viscous sputum cannot be effectively discharged, the treatment effect will be significantly reduced [12].

Sputum suction by fiberoptic bronchoscope can effectively clear a large number of secretions in the airway and restore the airway patency. Repeated lavage with normal saline can dilute the exudates and make them easier to discharge. Moreover, repeated lavage with normal saline can reduce inflammatory factors, alleviate local inflammation and enhance the effect of anti-infection treatment [13, 14]. In this study, the total effective rate after the treatment in the observation group was 94.12%, higher than the control group. The mechanical ventilation time, length of stay in ICU and duration of antibiotics in the observation group were shorter than those in the control group. The above results indicate that on the basis of conventional treatment, sputum suction and lavage by fiberoptic bronchoscope can significantly shorten the length of stay in ICU, mechanical ventilation time and duration of antibiotics, and its treatment effect is better than that of vibration expectoration. These are similar to the results of Chen et al., which also pointed out that for patients with severe pneumonia, the effect of sputum suction by fiberoptic bronchoscope was significantly better than that of conventional sputum suction tube, and the length of stay in ICU was significantly shortened [15]. It is speculated that because the fiberoptic bronchoscope can look directly at the lesions and avoid blind suction, resulting in a more obvious suction effect. Besides, repeated lavage with normal saline can dilute the respiratory tract exudate and sputum, which is more conducive to the discharge of sputum, so the sputum suction effect is extraordinary [16].

Anti-infection treatment is important for severe pneumonia. However, with the irrational use of antibiotics, drug-resistant strains have gradually increased, and the effect of simple anti-infection treatment is extremely limited [17]. In patients with severe pneumonia, the lung inflammation is obvious. Many inflammatory mediators gather in the lung tissue, and the increase of viscous sputum further aggravates the lung inflammation. Anti-infection alone cannot achieve the ideal therapeutic effect [18]. CRP, TNF-α and PCT are commonly used indicators to evaluate the body's inflammatory state. Higher levels of TNF-α, CRP and PCT indicate a more serious inflammatory state [19, 20]. In this study, after the treatment, the serum levels of TNF-α, CRP and PCT in the observation group were lower than the control group, suggesting that on the basis of conventional treatment, sputum suction and lavage with fiberoptic bronchoscope can more significantly control the inflammatory reaction in patients with severe pneumonia. This is because sputum suction by fiberoptic bronchoscope can discharge a large amount of sticky sputum, which is not easy to cough up in patients' respiratory tract, reducing the inflammatory stimulation of sputum on the respiratory tract. Also, repeated lavage with normal saline dilutes the inflammatory exudate, so sputum suction by fiberoptic bronchoscope helps control the body's inflammation [21]. A large number of inflammatory mediators in the airway of patients with severe pneumonia can damage airway epithelial cells, lead to lung ventilation dysfunc-

Table 4. Comparison of serum inflammatory factors before and after the treatment between the two groups ($\bar{x}$±sd)

Group	Time	CRP (mg/L)	TNF-α (ng/L)	PCT (ng/mL)
Observation group (n=51)	Before treatment	75.59±6.97	186.69±16.55	2.44±0.40
	After treatment	21.37±4.33[a,b]	77.70±10.42[a,b]	0.87±0.22[a,b]
Control group (n=52)	Before treatment	76.28±5.76	187.85±15.47	2.51±0.54
	After treatment	33.09±4.84[a]	101.10±12.39[a]	1.43±0.47[a]

Note: Compared with the same group before treatment, [a]P<0.05; compared with the control group after treatment, [b]P<0.05. CRP: C-reactive protein; TNF-α: tumor necrosis factor-α; PCT: procalcitonin.

Table 5. Comparison of blood gas analysis before and after the treatment between the two groups ($\bar{x}$±sd)

Group	Time	PaO_2 (mmHg)	SaO_2 (%)	OI
Observation group (n=51)	Before treatment	53.39±4.49	84.40±4.75	203.30±14.47
	After treatment	94.48±4.04[a,b]	98.10±3.44[a,b]	322.22±15.20[a,b]
Control group (n=52)	Before treatment	53.85±5.37	83.98±5.10	204.26±15.62
	After treatment	80.86±5.40[a]	92.12±3.22[a]	294.80±13.36[a]

Note: Compared with the same group before treatment, [a]P<0.05; compared with the control group after treatment, [b]P<0.05. PaO_2: arterial partial pressure of oxygen; SaO_2: arterial saturation of oxygen; OI: oxygenation index.

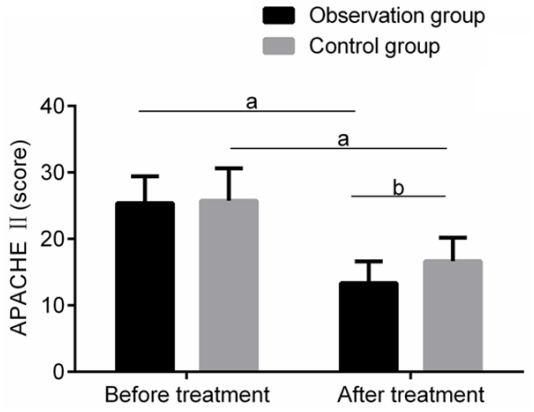

Figure 1. Comparison of APACHE II scores before and after the treatment between the two groups. Compared with the same group before treatment, [a]P<0.05; compared with the control group after treatment, [b]P<0.05. APACHE II: Acute Physiology and Chronic Health Evaluation.

tion, block the exchange of CO_2 and external O_2 and quickly lead to hypercapnia [22]. In this study, after the treatment, PaO_2, SaO_2 and OI of the observation group were higher than those of the control group. The APACHE II scores of the observation group were lower than those of the control group. The above results suggest that sputum suction and lavage with fiberoptic bronchoscope can more significantly improve the blood gas index and prognosis of patients with severe pneumonia, consistent with the results of Ma et al. [23].

However, this study is a single-center clinical study with a limited sample size. Only the changes of relevant indexes before and after the treatment were investigated. The effect of sputum suction by fiberoptic bronchoscope on pulmonary function and blood gas after hospital discharge still needs further investigation.

To sum up, conventional treatment combined with sputum suction and lavage by fiberoptic bronchoscope can significantly control the inflammatory state of patients with severe pneumonia, improve their blood gas and promote the treatment effect, which is worthy of clinical promotion.

Disclosure of conflict of interest

None.

Address correspondence to: Zhongtie Lin, Department of Infectious Diseases, Yongjia People's Hospital, No. 37 Yongzhong Road, Shangtang Town, Yongjia County, Wenzhou 325100, Zhejiang Province, China. Tel: +86-0577-57762643; E-mail: jinjian3188@126.com

References

[1] Mizgerd JP. Pathogenesis of severe pneumonia: advances and knowledge gaps. Curr Opin Pulm Med 2017; 23: 193-197.

[2] Chahin A and Opal SM. Severe pneumonia caused by legionella pneumophila: differential

diagnosis and therapeutic considerations. Infect Dis Clin North Am 2017; 31: 111-121.
[3] Wu WF, Fang Q and He GJ. Efficacy of corticosteroid treatment for severe community-acquired pneumonia: a meta-analysis. Am J Emerg Med 2018; 36: 179-184.
[4] Cinesi Gómez C, Peñuelas Rodríguez Ó, Luján Torné M, Egea Santaolalla C, Masa Jiménez JF, García Fernández J, Carratalá Perales JM, Heili-Frades SB, Ferrer Monreal M, de Andrés Nilsson JM, Lista Arias E, Sánchez Rocamora JL, Garrote JI, Zamorano Serrano MJ, González Martínez M, Farrero Muñoz E, Mediano San Andrés O, Rialp Cervera G, Mas Serra A, Hernández Martínez G, de Haro López C, Roca Gas O, Ferrer Roca R, Romero Berrocal A and Ferrando Ortola C. Clinical consensus recommendations regarding non-invasive respiratory support in the adult patient with acute respiratory failure secondary to SARS-CoV-2 infection. Arch Bronconeumol 2020; 56 Suppl 2: 11-18.
[5] Jiao X, Xu X and Ma A. Clinical observation of expectoration through pulse vibration applied to the patients with chronic obstructive pulmonary disease. Panminerva Med 2021; 63: 234-235.
[6] Ranzani OT, Senussi T, Idone F, Ceccato A, Li Bassi G, Ferrer M and Torres A. Invasive and non-invasive diagnostic approaches for microbiological diagnosis of hospital-acquired pneumonia. Crit Care 2019; 23: 51.
[7] Dhungana A and Thapa A. Flexible bronchoscopic removal of a forgotten intrabronchial foreign body. J Nepal Health Res Counc 2019; 16: 470-472.
[8] Chinese Society of Respiratory Diseases, Chinese Medical Association. Guidelines for diagnosis and treatment of community-acquired pneumonia in Chinese adults (2016 edition). Chin J Tuberc Respir Dis 2016; 39: 253-279.
[9] Sachdev A and Chhawchharia R. Flexible fiberoptic bronchoscopy in pediatric practice. Indian Pediatr 2019; 56: 587-593.
[10] Huang J, Xuan D, Li X, Ma L, Zhou Y and Zou H. The value of APACHE II in predicting mortality after paraquat poisoning in Chinese and Korean population: a systematic review and meta-analysis. Medicine (Baltimore) 2017; 96: e6838.
[11] Azoulay E, Russell L, Van de Louw A, Metaxa V, Bauer P, Povoa P, Montero JG, Loeches IM, Mehta S, Puxty K, Schellongowski P, Rello J, Mokart D, Lemiale V and Mirouse A. Diagnosis of severe respiratory infections in immunocompromised patients. Intensive Care Med 2020; 46: 298-314.
[12] Ziegler B, Hundeshagen G, Uhlmann L, Will Marks P, Horter J, Kneser U and Hirche C. Impact of diagnostic bronchoscopy in burned adults with suspected inhalation injury. Burns 2019; 45: 1275-1282.
[13] Menzella F, Montanari G, Patricelli G, Cavazza A, Galeone C, Ruggiero P, Bagnasco D and Facciolongo N. A case of chronic eosinophilic pneumonia in a patient treated with dupilumab. Ther Clin Risk Manag 2019; 15: 869-875.
[14] Han Q, Chen C, Fu R, Tan L and Xia L. Portable fibrobronchoscopic treatment for non-severe ischemic stroke-associated pneumonia patients with dysphagia: a pilot study. Neurol Res 2019; 41: 216-222.
[15] Chen L, Cheng J and Wang YL. Effects of different anaesthetics on cytokine levels in children with community-acquired pneumonia undergoing flexible fibreoptic bronchoscopy. J Int Med Res 2016; 44: 462-471.
[16] Cobo P, Vetter-Laracy S, Beltran E, Peña-Zarza JA, Figuerola J and Osona B. Utility of fiberoptic bronchoscopy for difficult airway in neonates. J Matern Fetal Neonatal Med 2021; 34: 2754-2757.
[17] Wongsurakiat P and Chitwarakorn N. Severe community-acquired pneumonia in general medical wards: outcomes and impact of initial antibiotic selection. BMC Pulm Med 2019; 19: 179.
[18] Garnacho-Montero J, Barrero-García I, Gómez-Prieto MG and Martín-Loeches I. Severe community-acquired pneumonia: current management and future therapeutic alternatives. Expert Rev Anti Infect Ther 2018; 16: 667-677.
[19] Tang JH, Gao DP and Zou PF. Comparison of serum PCT and CRP levels in patients infected by different pathogenic microorganisms: a systematic review and meta-analysis. Braz J Med Biol Res 2018; 51: e6783.
[20] Cui N, Zhang H, Chen Z and Yu Z. Prognostic significance of PCT and CRP evaluation for adult ICU patients with sepsis and septic shock: retrospective analysis of 59 cases. J Int Med Res 2019; 47: 1573-1579.
[21] Shi Z, Qin Y, Zhu Y, Pan X, Zhou X, Tan Y and Liu Y. Effect of bronchoalveolar lavage with fiberoptic bronchoscopy combined with vibration sputum drainage on mechanically ventilated patients with severe pneumonia: a prospective randomized controlled trial in 286 patients. Zhonghua Wei Zhong Bing Ji Jiu Yi Xue 2017; 29: 66-70.
[22] Ding L, Wang L, Ma W and He H. Efficacy and safety of early prone positioning combined with HFNC or NIV in moderate to severe ARDS: a multi-center prospective cohort study. Crit Care 2020; 24: 28.
[23] Ma W, Hu J, Yang M, Yang Y and Xu M. Application of flexible fiberoptic bronchoscopy in the removal of adult airway foreign bodies. BMC Surg 2020; 20: 165.