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Original Article

A randomized controlled study: the effect of endobronchial blocker and double-lumen endobronchial tube on one-lung ventilation in thoracic spinal tuberculosis surgery

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Abstract: Objective: To compare the effect of endobronchial blocker and double-lumen endobronchial tube on one-lung ventilation in thoracic spinal tuberculosis surgery. Methods: A total of 160 patients with thoracic spinal tuberculosis who were treated with thoracic surgery under one-lung ventilation from January 2015 to December 2016 in our hospital were selected as subjects. Patients were divided into group 1 (using double-lumen endobronchial tube) and group 2 (using endobronchial blocker) according to the method of random number table. The differences in scores of surgical field quality , time of lung collapse, success rate of cannula, and partial pressure of carbon dioxide ($PaCO_2$), partial pressure of oxygen (PaO_2), platform airway pressure (Pplat), and peak airway pressure (Ppeak) during one-lung ventilation and two-lung ventilation between two groups were compared. After operation, the occurrence of hoarseness, pulmonary infection, pharyngalgia and other complications of patients were evaluated by professional anesthetists. Results: Scores of surgical field quailty and time of lung collapse in group 2 were higher than those in group 1 while the one-time success rate of intubation was significantly lower than that in group 1 (all $P<0.001$). The PaO_2 of both groups after one-lung ventilation was lower than that after anesthesia and recovery of double-lumen ventilation (all $P<0.05$). And PaO_2 60 minutes after one-lung ventilation was lower than that 20 minutes after one-lung ventilation (all $P<0.05$). PaO_2 at each time point during one-lung ventilation in group 1 was lower than that in group 2 (all $P<0.05$). There was no significant difference in $PaCO_2$ between two groups at each time point (all $P>0.05$). Ppeak and Pplat of two groups were elevated during one-lung ventilation and it was found that Ppeak and Pplat in group 1 were higher than those in group 2 at different time points (all $P<0.05$). The incidence of complications of hoarseness, pulmonary infection, and pharyngalgia after operation in group 2 was lower than that in group 1 (all $P<0.05$). Conclusion: Endobronchial blocker for thoracic surgery was worthy of clinical promotion because when compared with double-lumen endobronchial tube, it has better visual field, slighter blood-gas changes and lower incidence of complications of hoarseness, pulmonary infection, and pharyngalgia after operation.

Keywords: Endobronchial blocker, double-lumen endobronchial tube, anesthesia

Introduction

Endobronchial blocker is positioned with the aid of fiberbronchoscope and then a standard single-lumen endobronchial tube was inserted [1]. This method is easy to operate and can achieve the effect of accurate position. In addition, double-lumen endobronchial tube can also achieve the effect of one-lung ventilation [2-5]. At present, these two methods are commonly used in the anesthesia process of clinical thoracic surgery, but there are few relevant reports about systematic comparisons of clinical applications [6]. Therefore, this study aims to study the effect of endobronchial blocker and double-lumen endobronchial tube on one-lung ventilation in thoracic spinal tuberculosis surgery (a common operation in thoracic surgery and used as an example). The specific operation and results are as follows.

Materials and methods

Case selection and grouping

A total of 160 patients with thoracic spinal tuberculosis who underwent thoracic approach focus clearance combined with internal fixation of posterior thoracic spine under general anesthesia from January 2015 to December 2016 were selected as subjects of the study. All patients' ASA were I-II. There were 92 males and 68 females, aged 45-67 years, weighted 45-80 kg and with the height of 150-180 cm and the body mass indexes (BMI) <30 kg/m^2.

Inclusion criteria: Patients who were older than 18 years and certainly diagnosed with thoracic spinal tuberculosis; patients' one-lung ventilation operated by the same doctor; patients were physically fit and could bear video-assisted thoracoscopic surgery; patients were informed and volunteered to participate in this study; patients with normal respiratory, cardiac, liver and kidney functions before surgery.

Exclusion criteria: Patients could not undergo video-assisted thoracoscopic surgery; patients had hoarseness, pharyngalgia and other pharyngolaryngeal symptoms before operation; patients had serious diseases of cardiovascular system, urinary system, etc.; patients underwent thoracic surgeries or pulmonary surgery before; patients received radiotherapy, chemotherapy or immunotherapy before surgery; patients had poor alignment in double-lumen endobronichial tube.

The study was approved by the Ethics Committee and all the patients enrolled in this study had signed informed consent forms. All the patients were numbered according to the method of random number table and then randomly divided into two groups group 1 (using double-lumen endobronchial tube) and group 2 (using endobronchial blocker).

Anesthesia methods

After all patients entered the operating room, their peripheral veins were first opened. Then the multiple lead electrocardiogram was established. Next, puncture and manometry were performed on the left radial artery and right internal jugular vein under oxygen saturation and local anesthesia.

Anesthesia induction was used in this research. Patients' mouths and noses were closely connected with ventilation mask, with the oxygen flow maintained at 8 L/min. After 2 min of preoxygenation, 0.04 mg/kg of midazolam, 1 μg/kg of fentanyl, 2 mg/kg of atracurium and 0.3 mg/kg of etomidate were injected via intravenous pathway. Mask would not be removed till the patient stopped autonomous respiration. The whole process of anesthesia induction was performed without mechanical ventilation.

Intubation method

Patients in group 1 were treated with the double-lumen endobronchial tube. The intubation procedure was as follows. After anesthesia induction, double-lumen endobronchial tube (male 37Fr, female 35Fr) was inserted under direct vision of laryngoscope. Firstly, the forepart of catheter was bent upwards and inserted with glottis, 21-23 cm away from incisor. Then tube core was pulled out. Next, the endobronchial blocker tube was lubricated, and the double-lumen tube was rotated along the longitudinal axis for 90° and then inserted continuously until the resistance occurred. Finally, under the guidance of bronchofiberscope, endobronchial blocker cuff was placed on the target bronchial side.

Patients in group 2 adopted the endobronchial blocker for treatment. The intubation procedure was as follows. A single-lumen endobronchial tube (male ID 7.5 mm, female 7.0 mm) was inserted into patients with depth of 22-24 cm, and fixed. Then the disposable endobronchial blocker was open so that the tracheal catheter connector could connect to anesthesia machine thread tube. Next, under mechanical ventilation, the single-lumen endobronchial tube was inserted into disposable endobronchial blocker with its forepart bent towards the side which would be blocked, and then inserted continuously until resistance occurred. Finally, under the guidance of bronchofiberscope, endobronchial blocker cuff was placed on the target bronchial side. During the operation, chest ventilation was stopped and 2 L/min of CO_2 was continually insufflated into right thoracic cavity. In the thoracic cavity, artificial pneumothorax was formed by maintaining the pressure of 8-10 mmHG (1 mmHG=133.3 Pa) to oppress the right lung collapse. When necessary, lung forceps were adopted to assist compression and exhaust residual lung gas [7-9].

Follow-up and outcomes

Primary outcome measures were as follows. The radial artery blood of the patients was col-

Table 1. Comparison of patients' general information in two groups

Group	Group 1	Group 2	Statistical value	*P* value
Sex ratio (male/female)	48/32	44/36	χ^2=0.409	0.522
Age (years)	44.21±5.14	43.34±4.28	t=1.163	0.246
Weight (kg)	63.34±5.31	62.32±3.19	t=1.471	0.143
Time of operation	154.2±23.7	149.5±25.5	t=1.208	0.229
Pulmonary plugging time	109.78±21.52	114.32±31.99	t=1.053	0.294
Intraoperative blood loss	200.4±12.7	198.5±16.6	t=0.813	0.417

Table 2. Comparison of patients' intubation in two groups

Group	Group 1	Group 2	Statistical value	*P* value
Operation visual field score (point)	1.74±0.38	2.92±0.45	t=17.92	<0.001
Lung collapse time (min)	2.89±0.39	4.38±0.53	t=20.25	<0.001
Success rate of one time cannula (n, %)	78 (97.5)	62 (77.5)	χ^2=-14.629	<0.001

lected at four time points: just after anesthesia, 20 minutes after one-lung ventilation, 60 minutes after one-lung ventilation and 10 minutes after the recovery of double-lung ventilation. Then, blood-gas analysis was performed immediately and the partial pressure of oxygen (PaO_2), partial pressure of carbon dioxide ($PaCO_2$), platform airway pressure (Pplat) and peak airway pressure (Ppeak) of the patients were recorded and compared. Besides, the patients' postoperative hoarseness, pharyngalgia, cough, pulmonary infection and other adverse reactions were observed and recorded; scores of surgical field quality were evaluated by attending physician: 3 points, lung did not collapse; 2 points, most of the lung collapsed, but there were still some gas remaining in the pulmonary alveoli; 1 point, the lung complete collapsed and the surgical visual fields were good.

Secondary outcome measures were as follows. The pulmonary obstruction time, sealing time of lung collapse in the occlusion side and the one-time success rate of intubation were recorded.

Statistical analysis

SPSS17.0 software was used for statistical analysis. The enumeration data were expressed as frequency and rate, and the chi-square test was applied for the comparison between two groups. The measurement data were expressed as mean ± standard deviation; the independent sample t-test was used to test the data (visual field score of operation (point) and lung collapse time (min)) at single time points; the data at multiple time points between two groups were compared by repeated measures analysis of variance followed by a Bonferroni post hoc test. The difference was statistically significant when $P<0.05$.

Results

General information of two groups

There was no statistical significance in differences between two groups of sex ratio, age, weight, pulmonary plugging time and so forth (all $P>0.05$). See **Table 1**.

Intubation condition of two groups

Scores of surgical field quality and time of lung collapse of group 2 were both higher than those of group 1, but the one-time success rate of intubation of group 2 was lower than that of group 1 ($P<0.05$). The difference was statistically significant. See **Table 2**.

Analysis of blood-gas at different time points of two groups

After one-lung ventilation, the PaO_2 of two groups was lower than that of post-anesthesia and after the restoration of double cavity ventilation. And the PaO_2 60 min after one-lung ventilation was lower than that 20 min after one-lung ventilation ($P<0.05$). Besides, PaO_2 at different time points after one-lung ventilation of group 1 were lower than those of group 2 (all $P<0.05$), the difference was statistically signifi-

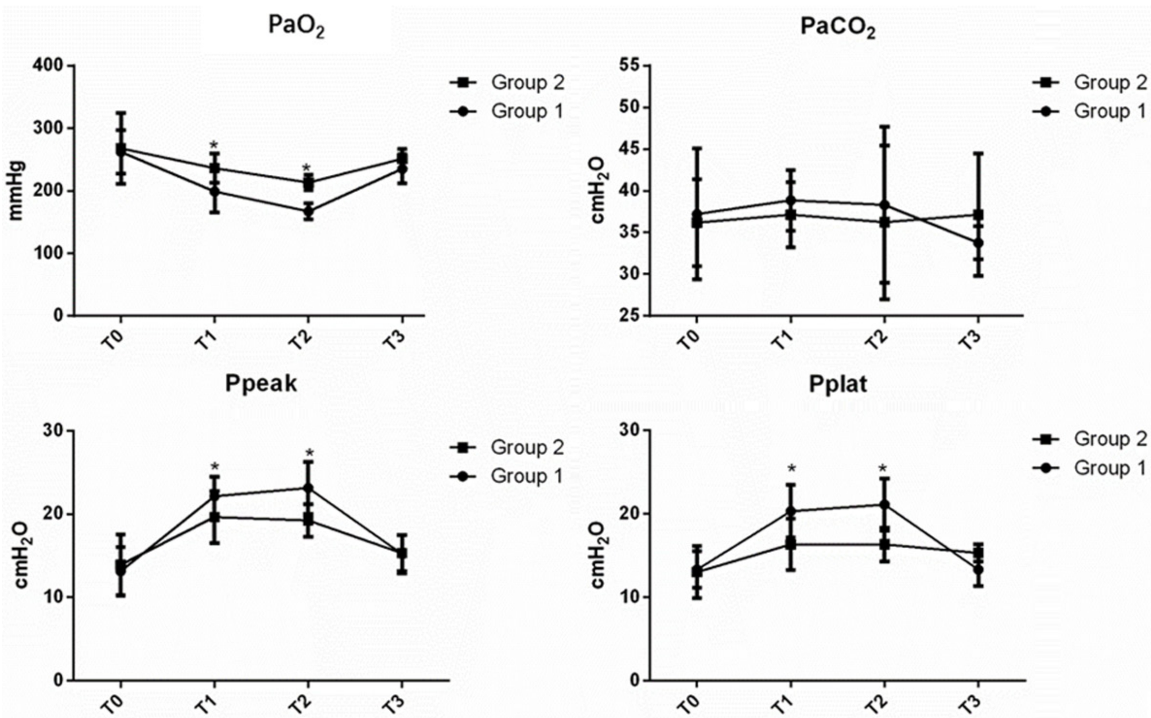

Figure 1. Blood gas analysis of two groups. T0: right after anesthesia; T1: 20 min after one-lung ventilation; T2: 60 min after one-lung ventilation; T3: 10 min after recovery of two lung ventilation; *P<0.05. Group 1 used double-lumen endobronchial tube and group 2 used endobronchial blocker.

Table 3. Comparison of postoperative complications in two groups

Group	Group 1 (n, %)	Group 2 (n, %)	χ^2	*P* value
Hoarseness and sore throat	18 (22.5)	6 (7.5)	7.059	0.008
Cough	4 (5)	0 (0.00)	4.103	0.043
Lung infection	4 (5)	0 (0.00)	4.103	0.043
Hypoxia	18 (22.5)	6 (7.5)	7.059	0.008
Total incidence	22 (27.5)	6 (7.5)	11.082	0.001

cant. The differences of $PaCO_2$ between two groups at various time points had no statistical significant (P>0.05). Compared with preanesthesia and before ventilation, the Ppeak and Pplat of two groups were all increased right after anesthesia, 20 min and 60 min after one-lung ventilation and decreased after 10 min of two-lung ventilation. However, after 20 min and 60 min of one-lung ventilation, Ppeak and Pplat of group 1 were both higher than those of group 2, with statistical significance (P<0.05). See **Figure 1**.

Postoperative complications of two groups

The incidence of postoperative complication of group 2 was lower than that of group 1, and the difference was statistically significant (P<0.05). See **Table 3**.

Discussion

Double-lumen endobronchial tube is a common technology for realizing one-lung ventilation in clinic. Clinical practice indicates that this technology requires high standard operation; what's more, the positioning of catheter and prevention of complications are difficult, leading to the extension of time in intubation and the requirement of high level skills of physician [10, 11].

The results revealed that operation visual field score and lung collapse time of endobronchial blocker group (group 2) were higher than those of double-lumen endobronchial tube group (group 1), but the success rate of one time intubation was lower than that of group 1, which was consistent with the studies of Campos and Ruetzler et al. [12, 13]. Based on previous literature and the real situation of this study, the author thought the reason of this phenomenon might as follows: using good double-lumen tube as cannula could be intubated in right place easily; after intubation, the main duct and bronchus part of the double-lumen could match with the trachea and bronchus of patients well (the diameter of the main duct and bronchus part of double-lumen tube was 1-2 mm smaller than those in patients); a small amount of inflation in cuff could form a good separation; the bronchial end located in the upper lobe bronchus proximal margin, the small cuff located between the upper lobe bronchus proximal margin and tracheal carina; and the lateral aperture of double-lumen tube overlay the orifice of bronchus in the other side [14].

Endobronchial blocker has a relatively small diameter, and its tube end is flexional, while bronchofiberscope can guide it into the bronchus in lobi pulmonis with accurate position so as to achieve the lobe collapse effect successfully [15]. A research showed that when patients with skinny and small body underwent one-lung ventilation, the thinner the double-lumen tube was, the stronger the airway resistance would be, which was not favorable to the redistribution of operation side pulmonary blood flow to unaffected side and the enhancement of oxygen saturation [16]. In this study, the endobronchial blocker tube was thinner than type 35Fr and 37Fr of double-lumen endobronchial tube, thus the compression of the double-lumen endobronchial tube to airway increased correspondingly [17-19]. Meanwhile, double-lumen endobronchial tube had higher success rate of one time intubation and positioning accuracy than endobronchial blocker [20]. The endobronchial blocker had a better operation visual field, which was mainly related to the operational procedures of two technologies. Double-lumen endobronchial tube is a kind of tube with double cavities, good ventilation and could preserve more gas, while less gas could be preserved in endobronchial blocker, which result in the better collapse degree in endobronchial blocker and the high visual field scores of operation [21]. Due to the fact that the exhaust pipe and suction catheter of endobronchial tube were relatively thin, it was necessary to open the cuff first and exhaust port later before performing one-lung ventilation, then the gas in lungs could be released slowly, thus taking a longer time [22]. This was a weakness of endobronchial blocker and could not be applied on the patients with wet lung, because the expectorate difficulties might trigger complications like airway obstruction and infection [23].

After one-lung ventalitation, PaO_2 of two groups were lower than those after anesthesia and restoration of double cavity ventilation. What's more, PaO_2 60 min after one-lung ventilation was lower than 20 min after it. And when one-lung ventilation was performed, PaO_2 of group 1 at each time point were all lower than those of group 2. Besides, Ppeak and Pplat in two groups were raised, but Ppeak and Pplat of group 1 at each time point were all higher than those of group 2. The possible reason for the results were as follows: first, after intubating 2-6 ml gas into tracheal cuff, its internal pressure was less than 25 cmH_2O, and there was no leakage when Ppeak was up to 30 cmH_2O; second, after intubating 1-3 ml gas into bronchial cuff, its internal pressure was less than 20 cmH_2O, and the isolation between two lungs was good when Ppeak was up to 30 cmH_2O; third, the blood-gas analysis of patients demonstrated that endobronchial blocker had little influence on patients' blood gas, especially on oxygen partial pressure, which ensured the oxygen supply of other tissues during operation and prevented the occurrence of hypoxia. Because hypoxia complications didn't occur in this study, it was unable to verify. So sample size could be increased in further study to investigate the effect of endobronchial blocker on hypoxia complications.

The deficiency of this study is the different injuries of two lungs during one-lung ventilation, and two lungs had different pathophysiologies in this process. Therefore, the difference in the impact of endobronchial blocker on ventilated side lung and pulmonary ventilation was not clear and needed further discussion.

To sum up, endobronchial blocker has better operation vision, less blood gas changes and lighter postoperative discomfort in the application of thoracic operation. As a safe and effective way, it is worthy of clinical promotion.

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Disclosure of conflict of interest

None.

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