

Comparison of tracheal intubation with controlled ventilation and laryngeal mask airway with spontaneous ventilation for thoracoscopic bullectomy

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Abstract

General anesthesia with double-lumen endobronchial intubation is considered mandatory for thoracoscopic bullectomy. We assessed the safety and feasibility of thoracoscopic bullectomy for treatment of primary spontaneous pneumothorax (PSP) under intubating laryngeal mask airway (ILMA) with spontaneous breathing sevoflurane anesthesia combined with thoracic paravertebral block (TPB).

From January 2018 to December 2018, some 34 consecutive patients with PSP were treated by thoracoscopic bullectomy under ILMA with spontaneous breathing sevoflurane anesthesia combined with TPB (study group). To evaluate the safety and feasibility of this new technique, these patients were compared with the control group consisting of 34 consecutive patients with PSP who underwent thoracoscopic bullectomy using tracheal intubation with controlled ventilation from January 2017 to December 2017. The demographic characteristics, intraoperative surgical and anesthetic results, and postoperative results were assessed.

The 2 groups had comparable anesthetic time, operation time, chest drainage time, postoperative hospital stays, and hospitalization cost. Visual analogue score (VAS) scores at 3 hours at rest and at coughing were significantly lower in the study group than in the control group (mean, 0.9 vs 2.0 and 1.8 vs 4.0, $P = .024$ and $P = .006$, respectively). No differences were seen in PaO₂ values between the 2 groups in the intraoperative stage and postoperative stage ($P > .05$, respectively). The pH value was significantly lower in the intraoperative stage (mean, 7.28 vs 7.40, $P = .01$) and higher in the postoperative stage (mean, 7.35 vs 7.33, $P = .014$) in the study group than in the control group. The PaCO₂ value was significantly higher in the intraoperative stage in the study group than in the control group (mean, 57.0 mm Hg vs 42.0 mm Hg, $P = .015$). In the study group, no cough reflex was found, and the level of collapse of the operative lung was excellent in 31 cases and good in 3 cases.

Our study demonstrated that thoracoscopic bullectomy for treatment of PSP can be safely and feasibly performed in highly selected patients under ILMA with spontaneous breathing sevoflurane anesthesia combined with TPB.

Abbreviations: ILMA = intubating laryngeal mask airway, PSP = primary spontaneous pneumothorax, TEB = thoracic epidural block, TPB = thoracic paravertebral block, VAS = visual analogue score.

Keywords: bullectomy, sevoflurane, spontaneous ventilation, thoracic paravertebral block, thoracoscopy

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The authors of this work have nothing to disclose.

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1. Introduction

Primary spontaneous pneumothorax (PSP) is a common clinical disease. Thoracoscopic bullectomy is an effective therapy for PSP.^[1] Currently, general anesthesia with double-lumen endobronchial intubation is considered mandatory for thoracoscopic bullectomy. However, double-lumen endobronchial intubation is related with sore throat, hoarseness, vocal cord lesions, and even airway rupture.^[2–4] Furthermore, 1-lung mechanical ventilation during operation may lead to barotrauma and volutrauma, which both can promote ventilator-induced acute lung injury.^[5–7] To avoid these complications, many authors explored the role of sole thoracic epidural block (TEB) without tracheal intubation for treatment of PSP.^[8–11] Nevertheless, TEB not only carries the risks of epidural abscess, epidural hematoma, dural puncture, and nerve injury,^[12] but also cannot completely suppress the cough of patients during pulmonary manipulation,^[9,13] which can hamper surgical maneuvers.

Thoracic paravertebral block (TPB) has been reported as an effective alternative to TEB in controlling postoperative pain while reducing the risks of epidural block,^[12] and sevoflurane anesthesia can inhibit bronchi receptors and attenuate protective responses.^[14] We hypothesized that thoracoscopic bullectomy

could be safely and feasibly performed under intubating laryngeal mask airway (ILMA) with spontaneous breathing sevoflurane anesthesia combined with TPB. Thus, a retrospective study was conducted to compare the safety and feasibility of thoracoscopic bullectomy using ILMA with spontaneous ventilation versus tracheal intubation with controlled ventilation for treatment of PSP.

2. Materials and methods

2.1. Study design and patients

This study was approved by the Ethics Committee of Beijing Friendship Hospital Affiliated to Capital Medical University (The document No.: 2018-P2-043-01). All patients underwent computed tomography (CT) examination before operation. Patients in the study group met the same surgical criteria as for patients in the control group. Inclusion criteria: ① patients with unilateral PSP requiring thoracoscopic bullectomy were included, ② no intrathoracic adhesions on the involved side, ③ Mallampati test grade I-II, ④ no comorbidity, ⑤ no coagulation disorders, ⑥ no mental disorders, ⑦ no contraindications for TPB, ⑧ no contraindications for laryngeal mask anesthesia, ⑨ body mass index (BMI) < 25. Exclusion criteria: ① previous thoracic surgery, ② history of infection on the involved side. From January 2018 to December 2018, some 34 consecutive patients were recruited and signed an informed consent form (study group). Thoracoscopic bullectomy was performed in these patients. The control group also included 34 consecutive patients with PSP who met the same inclusion/exclusion criteria, underwent thoracoscopic bullectomy under general anesthesia with double-lumen endobronchial intubation from January 2017 to December 2017. All the operations were performed by the same group of surgeons and anesthesiologists.

2.2. Anesthesia management

All patients fasted for at least 8 hours before operation. After entering the room, electrocardiogram, pulse oxygen saturation, arterial blood pressure, bispectral index (BIS), and end-tidal carbon dioxide were monitored.

In the study group, after the patient was placed in the lateral decubitus position, anesthesia was induced with sufentanil 0.1 μ g/kg and propofol 2.5 mg/kg. The ILMA, size 4 for males and size 3 for females, was inserted at the time of jaw relaxation. When the ILMA was difficult to insert, propofol 0.5 mg/kg was then injected. After insertion of the ILMA, TPB was performed in the fifth thoracic paravertebral space under ultrasound guidance, and 20 mL of 0.5% ropivacaine and 10 mg dexamethasone was administered at least 15 minutes before skin incision. Anesthesia was maintained using sevoflurane with an oxygen flow rate of 2 L/min with 100% oxygen. The concentration of sevoflurane was adjusted to maintain BIS values between 40 and 60. Sevoflurane was discontinued at the end of the surgery and the ILMA was removed when the patient regained consciousness. Then, the patient was transferred to the postanesthesia care unit.

In the control group, anesthesia was induced by intravenous injection of sufentanil 0.3 μ g/kg, propofol 2 mg/kg, and rocuronium 0.6 mg/kg and then a left-sided double-lumen endotracheal tube was inserted. During 1-lung ventilation, mechanical ventilation of the lung (tidal volume: 6–8 mL/kg, inspiratory

and expiratory ratio:1:1–1:2) was adjusted to maintain normocapnia (end-tidal carbon dioxide concentration, 35–45 mm Hg), and keep the airway pressure no more than 30 cmH₂O. Anesthesia was maintained with 1.0% to 2.5% sevoflurane with an oxygen flow rate of 2 L/min with 100% oxygen and 0.1 to 0.3 μ g/kg/min remifentanyl. The concentration of sevoflurane was adjusted to maintain BIS values between 40 and 60. After extubation in the operating room, the patient was transferred to the postanesthesia care unit.

2.3. Surgical procedure

Identical surgical techniques were used in all patients and all operations were performed by single surgeon. Thoracoscopic bullectomy was performed by a 2-port technique. The camera was inserted in the seventh intercostal space and the operative trocar port was placed in the fifth or fourth intercostal space. Targeted bullae were resected using a linear endoscopic stapler. If no blebs are identified, a small portion of the apex of the lung was resected. Additional pleurodesis with iodopovidone was performed by insufflation under thoracoscopic guidance. Then, warm saline was instilled into the thoracic cavity and the operated lung was dilated by manually positive-pressure ventilation to check for leaks. Afterwards, 1 chest drainage was positioned under direct camera visualization. After the wound was sutured, the operated lung was re-expanded by manually positive-pressure ventilation.

2.4. Data analysis

For each patient, demographic characteristics, anesthesia time, operative time, rates of conversion, postoperative stay, chest drainage time, and hospitalization cost were recorded. In the study group, the incidence of intraoperative cough reflex and collapse of the operative lung stratified into 4 levels by the surgeon: excellent, good, satisfactory, or unsatisfactory were recorded. Arterial blood gas analysis was recorded at preoperative stage of 1 day before operation, intraoperative stage of bullectomy, and postoperative stage at 1 hour after operation. At 3 and 24 hours after surgery, the patients were asked to rate their chest pain with visual analogue score (VAS) (0 = no pain, 10 = maximum pain imaginable). In both groups, parecoxib sodium (40 mg/12 h) was injected intravenously, and morphine 10 mg was injected subcutaneously as rescue drug if VAS score was greater than 4.

SPSS Version 22.0 (SPSS Inc., Chicago, IL) was used for statistical analysis. Continuous variables were expressed as mean \pm standard deviation (SD). Demographic and perioperative variables were compared using *t*-test or Mann–Whitney test, while the data were not normally distributed. Repeated measures analysis of variance (ANOVA) was used to compare pH, PCO₂, and PaO₂ according to the measurement time and the group, and *t*-test was used to evaluate the significance of group differences. Categorical variables were expressed as frequencies (%) and Fisher exact test was carried out to compare differences between the 2 groups. *P* < .05 was accepted to indicate statistical significance.

3. Results

Demographic characteristics are summarized in Table 1. There were no differences between the age, weight, gender, height, BMI, sex, and operation side of the 2 groups.

Table 1
Demographic characteristics.

Variable	Study group (n = 34)	Control group (n = 34)	P
Age, y	20.6 ± 5.0	22.9 ± 5.5	.228
Weight, kg	57.4 ± 8.9	55.1 ± 8.6	.471
Height, cm	173.9 ± 10.5	174.8 ± 6.4	.754
BMI	18.9 ± 2.1	18.0 ± 2.6	.309
Sex (male)	26 (76.5%)	27 (79.4%)	.833
Operation side (left)	21 (61.8%)	19 (55.9%)	.715

Continuous variables are expressed as mean ± standard deviation and categorical variables as number (%).

BMI=body mass index.

The surgical and anesthetic results are summarized in Table 2. The 2 groups had comparable anesthetic time and operation time. In the study group, the level of collapse of the operative lung was excellent in 31 cases and good in 3 cases. No cough reflex was found in the study group. Conversion to tracheal intubation was not required in the study group. No conversions to thoracotomy were performed in the 2 groups.

We compared chest drainage time, postoperative hospital stays, VAS at 3 and 24 hours postoperatively, and hospitalization cost between the 2 groups (Table 3). There were no differences in chest drainage time, postoperative hospital stays, and hospitalization cost between the 2 groups. VAS scores at 3 hours at rest and at coughing were significantly lower in the study group than in the control group ($P < .05$). However, there was not statistically significant in VAS scores at 24 hours at rest and at coughing between the 2 groups.

We compared perioperative pH, PaO₂, and PaCO₂ values according to the measurement time for the 2 groups (Fig. 1). There were no differences in pH, PaO₂, and PaCO₂ values in the preoperative stage between the 2 groups. No differences were seen in PaO₂ values between the 2 groups in the intraoperative stage and postoperative stage ($P > .05$, respectively). The value of pH was significantly lower in the intraoperative stage (mean, 7.28 vs 7.40, $P = .01$) and higher in the postoperative stage (mean, 7.35 vs 7.33, $P = .014$) in the study group than in the control group. The value of PaCO₂ was significantly higher in the intraoperative stage in the study group than in the control group (mean, 57.0 mm Hg vs 42.0 mm Hg, $P = .015$). In the study group, the intraoperative and postoperative pH values were significantly

Table 2
Surgical and anesthetic results.

Variable	Study group (n = 34)	Control group (n = 34)	P
Mean anesthetic time, min	92.3 ± 25.4	88.0 ± 24.2	.628
Mean operation time, min	53.8 ± 21.2	56.1 ± 16.2	.732
The level of collapse of the operative lung			
excellent	31 (91.2%)		
Good	3 (8.8%)	N/A	
satisfactory	0 (0%)		
Unsatisfactory	0 (0%)		
the incidence of intraoperative cough reflex (%)	0 (0%)	N/A	
Conversion to intubation (%)	0 (0%)	N/A	
Conversion to thoracotomy (%)	0 (0%)	0 (0%)	–

Continuous variables are expressed as mean ± standard deviation and categorical variables as number (%).

Table 3
Postoperative results.

Variable	Study group (n = 34)	Control group (n = 34)	P
Chest drainage time, d	3.2 ± 1.4	3.8 ± 1.4	.224
Postoperative hospital stays, d	7.1 ± 1.9	7.8 ± 3.4	.497
VAS			
3h at rest	0.9 ± 0.9	2.0 ± 0.6	.024
3h at coughing	1.8 ± 1.2	4.0 ± 1.7	.006
24h at rest	1.4 ± 0.5	2.0 ± 1.1	.179
24h at coughing	3.0 ± 1.3	3.7 ± 2.5	.471
Hospitalization cost (Yuan*)	27,629.9 ± 3768.6	28,494.2 ± 6100.5	.652

Continuous variables are expressed as mean ± standard deviation.

VAS=visual analogue score.

*The basic unit of money in China.

reduced compared with the preoperative value (mean, 7.28 vs 7.39 and 7.35 vs 7.39, $P = .009$ and $P = .000$, respectively), the intraoperative PaCO₂ value was significantly elevated compared with the preoperative value (mean, 57.0 mm Hg vs 42.7 mm Hg, $P = .014$). In the control group, the postoperative pH value was significantly reduced compared with the preoperative value (mean, 7.33 vs 7.38, $P = .000$), the postoperative PaCO₂ value was significantly elevated compared with the preoperative value (mean, 46.2 mm Hg vs 42.4 mm Hg, $P = .000$).

4. Discussion

Presently, thoracoscopic bullectomy is usually performed under general anesthesia with double-lumen intubation. In order to avoid potential complications associated with double-lumen intubation and 1-lung mechanical ventilation,^[2-7] we have evaluated the safety and feasibility of thoracoscopic bullectomy for treatment of PSP under ILMA with spontaneous breathing sevoflurane anesthesia combined with TPB. Our study suggests that thoracoscopic bullectomy can be safely and feasibly performed under ILMA with spontaneous breathing sevoflurane anesthesia combined with TPB: the surgical space was adequately large, and the nondependent lung could be safely manipulated.

The main purposes of using 1-lung ventilation with muscle paralysis in thoracoscopic bullectomy is to provide enough space for surgical maneuvers and suppress cough reflex. Our results showed that the operative lung was almost completely deflated in the study group. Thus, an enough operation space was provided for the movement of thoracoscopic instruments. Cough reflex, which can hamper intraoperative surgical maneuvers, is one of inevitably encountered problems when performing nonintubated thoracoscopic bullectomy. Cough reflex is initiated by the activation of the chemically and mechanically sensitive vagal nerves innervating airways. Excessive stretch of the nondependent lung can trigger persistent cough, which can interfere with the operation itself. Cough reflex was described by Guo et al^[13] with total intravenous anesthesia combine with TEB in 1% of cases, and Pompeo et al^[9] with awake TEB in 14% of cases. Intraoperative vagal block is an effective way to suppress cough reflex during 12 hours,^[15] and routinely used in some studies.^[16,17] However, vagal blockade may raise the risks of nerve injury, adjacent vessel damage, or aspiration.^[8,18] Furthermore, residual vagal blockade may negate the positive benefits of cough reflex, an important protective mechanism that can help reduce postoperative respiratory complications.^[19] Thus, intrathoracic vagal block was not performed in our study, and sevoflurane that

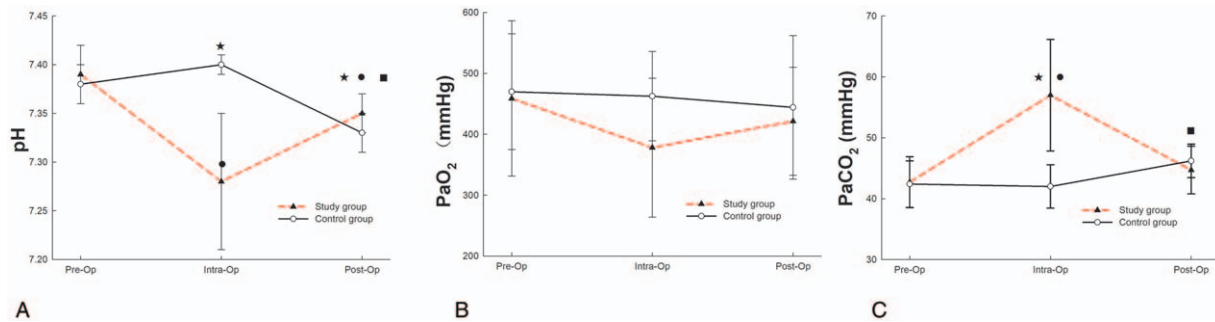


Figure 1. The perioperative changes of (A) pH, (B) PaO₂, and (C) PaCO₂ in the 2 groups. Data are presented as mean ± standard deviation. Pre-OP = preoperative stage of 1 day before operation, Intra-OP = intraoperative stage of bullectomy, Post-OP = postoperative stage at 1h after operation. **P* < .05 compared between the 2 groups. ●*P* < .05 compared with preoperative stage of the study group. ■*P* < .05 compared with preoperative stage of the control group.

can inhibit pulmonary irritant receptors was inhaled to suppress cough reflex.^[18] In our study, no cough reflex was observed when the nondependent lung parenchyma was manipulated in the study group. This suggests that inhalation of sevoflurane is an effective way to suppress cough reflex during nonintubated thoracoscopic bullectomy.

Hypoxemia and permissive hypercapnia are also commonly seen due to “re-breathing” of exhaled air and surgical pneumothorax in nonintubated thoracoscopic bullectomy.^[15] In our study, no patients developed hypoxemia, and the intraoperative PaO₂/FiAO₂ level remained satisfactory (>300 mm Hg) in the study group. There are some devices available to support patient oxygenation, including oropharyngeal cannula, high-flow oxygen nasal prongs, the laryngeal mask airway, and facial mask,^[15] but our team prefers ILMA. Oxygenation can be ensured by ILMA, and even an endobronchial blocker can be placed through it if necessary.^[20,21] And the intraoperative PaCO₂ level (mean 57.0 mm Hg) in the study group did increase significantly because of “re-breathing” of exhaled air and respiratory depression, but returned to normal values 1 hour after surgery, furthermore considering that many studies describe a transient intraoperative hypercapnia, this value is still tolerable.^[22–24] In fact, the use of spontaneous breathing inhalation anesthesia can permit a self-limiting regulation of the inhaled gas, thus avoiding the occurrence of severe respiratory depression. In addition, the presence of ILMA can safely and easily manage any possible respiratory depression, which were reported during thoracoscopy performed under sedation-assisted local anesthesia by Chhajed et al.^[25] Therefore, in our study, because of the use of ILMA, no patients were converted to tracheal intubation due to hypoxemia and hypercapnia. In the postoperative stage, although there was no difference between the 2 groups in PaCO₂ value, the PaCO₂ value in the control group was significantly higher than the preoperative value, and the pH value was also significantly lower than that in the study group. This may be mainly due to the good analgesic effect of paravertebral block used in the study group, avoiding the respiratory inhibition caused by insufficient analgesia.

The acute pain following thoracoscopic bullectomy can be severe.^[26,27] Severe postoperative pain was significantly correlated with recovery process and patient comfort.^[28,29] In our study, the VAS scores at rest were mild (VAS ≤3 cm) in both groups, but the VAS scores at 3 hours both at rest and at coughing were lower in the study group than in the control group. This suggests that preoperative single-dose TPB can improve postop-

erative acute pain, which also has been proved by other articles.^[30–32] Furthermore, preoperative single-dose TPB can provide excellent intraoperative analgesia. In the study group, in addition to the use of small doses of sufentanil during induction, no additional sufentanil was used. TPB is simple and easy to learn, safe to perform in sedated and ventilated patients, and safer and easier than TEB.^[33] As an analgesic method as effective as TEB in controlling postoperative acute pain,^[12] the use of TPB for thoracoscopic surgery is well accepted.^[34]

Furthermore, inhalation of sevoflurane general anesthesia combined with TPB can avoid other adverse events of awake thoracoscopic bullectomy with sole use of TEB. These adverse events including thoracic pain at trocars sites (9.5%) and panic attack (9.5%)^[9] were associated with the fact that patients were not asleep but sedated, and completely absent in our study because all the patients were asleep (BIS value: 40–60). In awake craniotomy, Milian et al^[35] reported that although most patients are satisfied with the surgery, 10% to 14% patients experienced strong anxiety. Intraoperative panic attack may cause post-traumatic stress disorder. So, when planning an awake thoracoscopy, it is important to pay close attention to every patient’s individual situation and avoid psychological sequelae.

Our article has limitations. First, this study is a retrospective study and nonrandomized patient selection, which may introduce bias into patient selection and management. Second, the sample size of the article is relatively small. So, further randomized controlled studies are needed to assess the potential advantages of this new technique in thoracoscopic bullectomy.

In summary, on the basis of our results, thoracoscopic bullectomy for treatment of PSP can be safely and feasibly performed under ILMA with spontaneous breathing sevoflurane anesthesia combined with TPB. This new technique provides enough space for surgical maneuvers, permits safe manipulation of the nondependent lung without cough reflex, provides good postoperative analgesia, and avoids risks associated with double-lumen endotracheal intubation.

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