CT 3-Dimensional Airway Reconstruction-guided Intraluminal Placement of Endobronchial Blocker in Pediatric Patients: A Randomized Controlled Study

Yingyi Xu  
Guangzhou Women and Children's Medical Center  https://orcid.org/0000-0001-8335-9198

Na Zhang  
Guangzhou Women and Children's Medical Center

Yonghong Tan  
Guangzhou Women and Children's Medical Center

Minting Zeng  
Guangzhou Women and Children's Medical Center

Jianning Hou  
Guangzhou Women and Children's Medical Center

Wei Liu (✉ liuwei19610624@126.com)  
Guangzhou Women and Children's Medical Center

Research article

Keywords: endobronchial blocker, pediatric anesthesia, CT 3-dimentional reconstruction, one-lung ventilation, bronchoscopy

DOI: https://doi.org/10.21203/rs.3.rs-46104/v1

License: ✅ This work is licensed under a Creative Commons Attribution 4.0 International License. 
Read Full License
Abstract

**Background:** The one-lung ventilation (OLV) with endobronchial blocking is commonly used in anesthesia for pediatric thoracic surgery. Bronchoscopy is commonly used to guide the endobronchial blocker placement. However, when bronchoscopy is not applicable, the proper placement of endobronchial blocker is challenging. The computed tomography (CT) 3-dimensional reconstruction may be used to accurately measure the airway of pediatric patients. The present study was aimed to propose a new approach of CT 3-dimensional airway reconstruction-guided endobronchial blocker placement in pediatric patients and to determine its efficiency in clinical application.

**Methods:** A total of 127 pediatric patients of 0.5-3 years old who would undergo elective thoracic surgery under OLV were randomized into the bronchoscopy group and the CT group. The degree of lung collapse, postoperative airway mucosal injury, pulmonary infection within 72 h after surgery, trachyphonia after tracheal extubation, durations of postoperative mechanical ventilation, intensive care unit (ICU) stay, and hospitalization, the successful rate of the first blocker positioning, and the required time and repositionings for successful blocker placement were compared between the two groups.

**Results:** The degree of lung collapse, postoperative airway mucosal injury, pulmonary infection within 72 h after surgery, trachyphonia after tracheal extubation, durations of postoperative mechanical ventilation, ICU stay, and hospitalization were similar between the two groups (all P > 0.05).

**Conclusions:** For pediatric patients who would undergo surgery with OLV, preoperative CT 3-dimensional airway reconstruction could be used to guide endobronchial blocker placement, with a blocking efficiency similar to that of bronchoscopy-guided blocker placement.

The trial was registered prior to patient enrollment at China Clinical Trial Registry (http://www.chictr.org.cn/showproj.aspx?proj=4344, Principal investigator: Yingyi Xu, Registration number: ChiCTR-TRC-14005232, Date of registration: 12 August 2014).

**Key Points**

**Question:** How to improve the successful rate of endobronchial blocker placement in pediatric patients when bronchoscopy is not applicable?

**Finding:** The blocking efficiency of computed tomography (CT) 3-dimensional airway reconstruction-guided endobronchial blocker placement was similar to that of bronchoscopy-guided blocker placement.

**Meaning:** When bronchoscopy is not applicable, preoperative CT 3-dimensional airway reconstruction could be used to guide endobronchial blocker placement in pediatric patients.

**Conflict of Interest Statement**

None of the authors have any financial conflicts of interests. This work was not supported by any grants.
Introduction

During anesthesia for thoracic surgery, one-lung ventilation (OLV) is very important because lung isolation is necessary for most thoracic surgeries to ensure clear surgical exposure\(^1,2\). For pediatric patients, several OLV techniques are available, including double-lumen tube and bronchus blocking\(^3\). However, conventional double-lumen tube and Univent\textsuperscript{TM} blocker are not suitable for infants and young children due to their large external diameters\(^4\), whereas the double-lumen tube (Marraro) designed for newborns and infants are not widely adopted yet\(^5\). Bronchial blocking is the most commonly used OLV technique for pediatric patients. Quick and proper blocker placement is the key of OLV, and bronchoscopy (BRO) is commonly used to guide endobronchial blocker placement in pediatric patients\(^6\). The blocking techniques include intraluminal and extraluminal blocking. For extraluminal blocking, the bronchial blocker and Tracheal tube need to be inserted together through the glottis and may cause airway mucosal injury with a high rate of postoperative traumatic laryngitis, and the bronchial blocker is hard to be fixed and is prone to move during surgery\(^7,8\). Intraluminal blocking causes less injury with certain blocking efficiency, but the application of bronchoscopy-guided positioning is limited by the diameter of the Tracheal tube for pediatric patients\(^9\). Only the Tracheal tube with an internal diameter greater than 4.5 mm could allow the simultaneous insertion of the bronchoscope and the finest bronchial blocker. Bronchoscopy-guided intraluminal blocking cannot be applied in pediatric patients who are too young or have a narrow airway that cannot allow the insertion of a Tracheal tube with an internal diameter greater than 4.5 mm. In addition, for institutions without fiberoptic bronchoscopy, such as some institutions in developing countries, how to properly place the endobronchial blocker in pediatric patients remains challenging.

Chest CT images could be used to accurately predict the optimal insertion depth of double-lumen Tracheal tube\(^10\) and guide extraluminal Uniblocker placement in the left bronchus in adult patients\(^11\). However, the airway anatomy is different between children and adults. In addition, the existence of abnormal take off of the right upper lung lobe makes the endobronchial blocker placement in the right bronchus harder than that in the left bronchus. Whether chest CT images could be used to guide endobronchial blocker placement in pediatric patients remains to be determined. We proposed a novel method of applying CT 3-dimentional reconstruction to measure the airway and guide endobronchial blocker placement in pediatric patients. In the present randomized prospective study, we compared the efficiency of endobronchial blocker placement guided by bronchoscopy and CT 3-dimentional reconstruction and determined the feasibility of applying preoperative helical CT 3-dimentional airway reconstruction to guide endobronchial blocker placement in pediatric patients.

Methods

Patient enrollment and randomization: This study was approved by the institutional ethical committee of Guangzhou Women and Children's Medical Center (No. 2014051229, approval date: June 3, 2014). The trial was registered prior to patient enrollment at China Clinical Trial Registry
(http://www.chictr.org.cn/showproj.aspx?proj=4344, Principal investigator: Yingyi Xu, Registration number: ChiCTR-TRC-14005232, Date of registration: 12 August 2014). Written informed consent was obtained from all patients enrolled in the study. Informed consent was signed by the guardians of each patient. Pediatric patients who would undergo elective thoracic surgery between September 2014 and June 2016 at Guangzhou Women and Children's Medical Center were selected. The enrollment criteria were as follows: (1) ASA stage I-III and (2) age of 0.5-3 years old. The exclusive criteria were as follows: (1) airway compression; (2) laryngeal edema or acute airway inflammation; (3) abnormal takeoff of the right upper lung lobe; (4) foreseeable difficulties in endotracheal intubation. The enrolled patients were randomized into the bronchoscopy (BRO) group and the CT group using the closed envelope technique. The endobronchial blocker placement was guided by bronchoscopy in the BRO group and by CT 3-dimentional airway reconstruction in the CT group. All cases of anesthesia were performed by a pediatric anesthetist with 6-year experience of thoracic anesthesia. Random numbers were generated using software (SAS 9.2, SAS Institute Inc, Cary, NC, USA) with a ratio of 1:1. These numbers were then sealed in envelopes and kept by an independent study coordinator who did not participate in anaesthesia, perioperative care and postoperative follow-up of the patients. During the study period, patients were consecutively recruited and randomly divided into the control or intervention group accordingly. Anaesthesiologists who gave anaesthesia did not participate patients’ follow up and data collection. Patients, healthcare providers and investigators who were in charge of follow-up and data collection, were blinded to the study protocol.

CT measurement: All pediatric patients received cervical and chest CT scanning (5 mm thickness, 5 mm interval, Aquilion 64, Toshiba) under sedation at the supine position for 3-dimentional airway reconstruction before surgery. The FH plane was determined with the bilateral auriculares and the orbitale; the median vertical plane was determined with the middle of sella turcica, the nasospinale, and the posterior edge of foramen magnum. The distance from the incisor teeth to the carina was measured at the vertical plane when the airway between the incisor teeth and the carina was clearly exposed; if the patient was not at a proper position or the airway was compressed, the distance would be measured after surface reconstruction (Figure 1).

Anesthesia: All pediatric patients received intravenous injection of 0.01 mg/kg penehyclidine hydrochloride before surgery and oxygen inhalation after entering the operation room. They received micro-pump infusion (8-10 ml/kg/h) of sodium acetate Ringer's injection, and their BP, HR, ECG, and SpO$_2$ were monitored. Midazolam (0.05 mg/kg), sufentanil (0.3 μg/kg), and rocuronium (0.6 mg/kg) were injected intravenously to induce general anesthesia. Then, a tracheal tube without side holes (Weili Medical Inc, Guangzhou, China) was intubated under direct vision of laryngoscopy. The catheter model was selected according to the calculation using the classic formula (based on predicted age formula). After intubation, the partial pressure of carbon dioxide in endexpiratory gas (PETCO$_2$) as well as invasive arterial blood pressure and central venous pressure were monitored, and tracheal aspiration was performed. Inhalation of 1%-3% sevoflurane was used for anesthesia maintenance with a tidal volume of 6-8 ml/kg. The concentration of sevoflurane was adjusted according to hemodynamic changes and data
of anesthesia monitoring. Rocuronium and sufentanil were supplemented while necessary. All patients were subjected to ICU care after surgery.

**Endobronchial blocker placement:** In the BRO group, the insertion depth of tracheal tube was calculated using the classic formula\(^ {12}\). After the 5 French (5F) Weili endobronchial blocker (Weili medical Inc, Guangzhou, Guangdong, China) was placed into the tracheal tube, an electrobronchoscope (A20-2.8, Maidehao Co, Zhuhai, Guangdong, China) with a diameter of 2.8 mm was inserted to help locate the endobronchial blocker until the point A of endobronchial blocker reached the take off of the main bronchus at the blocking side (Figure 2). The proper blocker placement was confirmed under bronchoscopy after the patients shifted from the horizontal position to the lateral position.

In the CT group, CT 3-dimensional reconstruction images were used to measure the length of the main bronchus (the length from the incisor teeth to the carina) before endobronchial blocker placement. Before endotracheal intubation, the insertion depth was preset as the CT-measured length of the main bronchus minus 2 cm and was marked (marker 1) on the tracheal tube (Figure 3a). The endobronchial blocker was inserted through the tracheal tube until the point A of the sacculus reached the catheter tip. The positions on the blocker which paralleled the screw cap (marker 2) and the screw cap plus 2 cm (marker 3) were marked, then the endobronchial blocker was extubated after the cap was screwed up (Figure 3b). The tracheal tube was inserted to marker 1 under direct-vision laryngoscopy. The endobronchial blocker was inserted through the tracheal tube again. The connectors of the endobronchial blocker and the tracheal tube were fixed when the screw cap paralleled marker 2. The endobronchial blocker was further inserted until the screw cap paralleled marker 3 with resistance disappeared, and the sacculus was inflated with 1.5-2.5 ml of air (Figure 3c). Both lungs were auscultated to make sure that respiratory sounds disappeared in the lung of the blocking side. If proper blocking was not achieved after 5 consecutive repositionings, bronchoscopy-guided placement would be applied, and the patient would be excluded. The proper blocker placement was confirmed by auscultation after the patients shifted from the horizontal position to the lateral position.

**Observational parameters:** (1) the required time for successful blocker placement (measured since the endobronchial blocker was inserted through the vocal cord until it was placed at the proper position); (2) the number of repositionings for successful blocker placement (each extubation of the endobronchial blocker from the Tracheal tube was counted as one repositioning); (3) the successful rate of the first blocker positioning; (4) the degree of lung collapse ranked by the surgeon as excellent (complete lung collapse at the blocking side), fair (lung collapse at the blocking side with a little amount of residual air that would not affect surgical exposure), moderate (partial lung collapse which requires suction or manual collapse), and poor (no collapse of the lung)\(^ {13}\); (5) airway mucosal injury graded using bronchoscopy after surgery by an anesthetist as none (no mucosal edema), mild (mild mucosal edema), moderate (obvious mucosal edema and hyperemia), severe (mucosal erosion and hemorrhage)\(^ {11}\); (6) pulmonary infection occurred within 72 h after surgery, which was defined as plaque-like shadow on both lungs with or without pleural effusion observed by chest X-ray; (7) trachyphonia after tracheal extubation;
(8) the duration of postoperative mechanical ventilation; (9) the duration of postoperative intensive care unit (ICU) stay; (10) the duration of postoperative hospitalization.

**Estimation of sample size:** The sample size was estimated with $\alpha = 0.05$ and $1-\beta = 0.8$ using the PASS 15.0 software (NCSS, Utah, USA). According to our previous clinical experience, the adequacy of lung collapse was similar in the two groups. According to the estimation, at least 61 patients in each group needed to be enrolled to find a moderate variation (i.e., $W = 0.3$) between the two groups.

**Statistical analyses:** The SPSS 15.0 software (NCSS, Utah, USA) was used for statistical analyses. Continuous data with normal distribution are expressed as mean ± standard deviation and were analyzed using the independent-sample $t$ test; continuous data with abnormal distribution are expressed as median (interquartile range) and were analyzed using the Wilcoxon rank-sum test; categorical data are expressed as cases (%) and were analyzed using the Pearson $\chi^2$ test or the $\chi^2$ test with correction for continuity. $P < 0.05$ was considered significant.

**Results**

A total of 127 pediatric patients were assessed for eligibility. Five patients were excluded due to the abnormal takeoff of the right upper lung lobe; 3 patients withdrew from the study after grouping because one-lung ventilation technique was deemed not necessary by the surgeon. Therefore, 119 patients were enrolled into this study (Figure 4). The two groups had no significant differences in demographic characteristics, including age, sex, weight, height, ASA stage, and thoracic surgery type ($P > 0.05$; Table 1).

The required time for successful blocker placement was significantly longer in the CT group than in the BRO group (124.9 ± 34.2 s vs. 92.9 ± 17.6 s, $P < 0.001$), successful blocker placement required more repositionings in the CT group than in the BRO group (1.22 ± 0.56 vs. 1.05 ± 0.28, $P < 0.05$), and the successful rate of the first blocker positioning was significantly lower in the CT group than in the BRO group (82.8% vs. 96.7%, $P < 0.05$) (Table 2). After blocking, the degree of lung collapse was excellent in 56 patients and fair in 2 patients from the CT group and was excellent in all the 61 patients from the BRO group, without significant difference ($P > 0.05$). After surgery, mild airway mucosal injury was observed in 2 patients from the CT group and 1 from the BRO group ($P > 0.05$). For both groups, 2 patients had pulmonary infection within 72 h after surgery, and 3 had trachyphonia after tracheal extubation (both $P > 0.05$). No significant differences in the durations of postoperative mechanical ventilation, ICU stay, and hospitalization were observed between the two groups (all $P > 0.05$).

**Discussion**

The insertion of the finest 5F endobronchial blocker requires a Tracheal tube with an internal diameter greater than 4.5 mm.$^{14}$ While applying OLV in pediatric patients, bronchoscopy cannot be used to guide intraluminal blocker placement if the insertion of a Tracheal tube with an internal diameter greater than
4.5 mm is not applicable. In the present study, we used chest CT 3-dimensional reconstruction to measure the airway and guide endobronchial blocker placement.

While comparing the techniques used for lung isolation, safety and efficiency should be considered. The adequacy of lung collapse affects surgical exposure and is a criterion for the assessment of successful OLV. In the present study, CT-guided endobronchial blocker placement achieved similar adequacy of lung collapse as compared with bronchoscopy-guided blocker placement in pediatric patients. The sacculuses of most endobronchial blockers are featured by small volume and high pressure, and excessive inflation may induce pressure mucosal injury; during sacculus inflation procedures, the advantage of direct vision under bronchoscopy was considered to be important for the prevention of sacculus inflation-caused mucosal injury in small bronchi. However, in the present study, no significant difference in airway mucosal injury was observed between the BRO and CT groups, suggesting that CT-guided endobronchial blocker placement would not increase the risk of airway mucosal injury. In addition, the rates of postoperative pulmonary infection and trachyphonia were similar in the two groups (P > 0.05). Regarding postoperative pulmonary recovery, no significant differences in the durations of mechanical ventilation, ICU stay, and hospitalization were observed between the two groups. Therefore, we consider that using CT 3-dimensional airway reconstruction to guide endobronchial blocker placement is feasible and safe.

We postulated that CT 3-dimensional reconstruction may be used to accurately estimate the insertion depth of Tracheal tube before blocking. The distance from point A to point B on the tip of endobronchial blocker is approximately 2 cm. Inserting the uncuffed Tracheal tube without side holes to 2 cm above the carina would leave enough space to allow the insertion of endobronchial blocker for laterobronchus blocking. In addition, by checking the markers on the endobronchial blocker during insertion, we could determine the optimal insertion depth in the bronchus of the blocking side. Therefore, CT 3-dimensional reconstruction-guided endobronchial blocker placement can be used for quick intraluminal blocking.

Narayanaswamy et al. reported that the median time to complete the placement procedures under the guidance of fiberoptic bronchoscopy was 203 seconds, whereas Campos et al. reported a duration of 158 seconds. Peng et al. reported that the placement time was 185 seconds. In the present study, it was 92.9 s in the BRO group and 124.9 s in the CT group, both were much shorter than those reported in literature. It may be explained by that endobronchial blocking was performed by anesthetists with 6-year experience of thoracic anesthesia in our center, who were skilled in performing both endobronchial blocking and bronchoscopy. In the present study, the required time was longer in the CT group than in the BRO group because CT-guided blocker placement required the assistance of auscultation, costing longer time than placing the blocker under direct vision through bronchoscopy.

The present study contained some limitations. First, the major limitation was that the adequacy of lung collapse relied on surgeons’ subjective assessment. Second, this was a single-center study, and the feasibility of using CT 3-dimensional airway reconstruction to guide endobronchial blocker placement needs to be validated in future multi-center studies. Third, pediatric patients with abnormal takeoff of the
right upper lung lobe were excluded. The application of CT-guided endobronchial blocker placement in these patients needs further investigation.

In conclusion, comparing with bronchoscopy-guided endobronchial blocker placement, CT-guided blocker placement achieved similar adequacy of lung collapse. Although CT guidance may increase the required time and repositionings for successful blocker placement, it will not increase bronchus mucosal injury and affect postoperative pulmonary recovery. Therefore, for pediatric patients who need to undergo surgery with OLV, CT 3-dimensional airway reconstruction is a simple and efficient technique for endobronchial blocker placement.

**Abbreviations**

computed tomography (CT)

one-lung ventilation (OLV)

intensive care unit (ICU)

bronchoscopy (BRO)

**Declarations**

**Ethics approval and consent to participate:** This study was approved by the Research Ethics Committee of Guangzhou Women and Children's Medical Center. Since the study was retrospective, the Research Ethics Committee of Guangzhou Women and Children's Medical Center agreed to waive patient parental consent to review their medical records. Images relating to participants in the manuscript were obtained with written informed consent from the guardian. The study protocol was complied with the 1975 Declaration of Helsinki.

**Consent for publication:** Not applicable.

**Availability of data and material:** All data are available from the corresponding author by request.

**Competing interests:** The authors declare that they have no competing interests

**Funding:** No specific funding from private and public sectors for this study.

**Acknowledgements:** Not Applicable

**Authors' contributions:**

(I) Conception and design: YX, WL;

(II) Administrative support: WL, YT;
(III) Provision of study materials or patients: YX, NZ, WW, WL;

(IV) Collection and assembly of data: YX, YT;

(V) Data analysis and interpretation: MZ, JH;

(VI) Manuscript writing: All authors;

(VII) Final approval of manuscript: All authors.

These authors contributed equally to this work.

**Authors' Information**

Yingyi Xu, M.M., Na Zhang, M.M., Wei, Wei, M.M., Yonghong Tan, M.D., Minting Zeng, M.M., Jianning Hou, M.M., Wei Liu, M.M.

Corresponding author: Wei Liu

**References**

1. Yamashita A, Okamoto H. Anesthesia for Thoracoscopic Surgery in Children. *Egypt J Cardiothorac Anesth*. 2016; 65(9):930–936.

2. Narayanasamy S, Adler E, Mahmoud M, Subramanyam R. One lung ventilation with Arndt pediatric bronchial blocker for thoracoscopic surgery in children: a unicentric Experience. Airway management of congenital pulmonary airway malformation resection in neonates and infants: A case cohort study *Pediatric Anesthesia*. 2019; 29(8):808–813.

3. Templeton LB, Lawrence AE, Lee, AJ. Inside out: Repurposing endobronchial intubation to facilitate extraluminal placement of a 5 FrArndt bronchial blocker in young infants. *Pediatric Anesthesia*. 2018; 28(7):668–669.

4. Hammer GB. Pediatric thoracic anesthesia. *Anesth Analg.*. 2001; 92:1449–1464.

5. Pawar DK, Marraro GA. One lung ventilation in infants and children:experience with Marraro double lumen tube. *Pediatr Anesth*. 2005; 15:204–364.

6. Meggiolaro KM, Wulf H, Feldmann C, Risse J. Endobronchial Blocker for onelung ventilation in children up to 24 months of age Airway management for lung separation in thoracic surgery : An update. *Anaesthesia*. 2018; 67(8):555–567.

7. Templeton TW, Downard MG, Simpson CR, Zeller KA, Templeton LB, Bryan YF. Bending the rules: a novel approach to placement and retrospective experience with the 5 French Arndt endobronchial blocker in children <2 years. *Pediatr Anesth*. 2016; 26:512–520.

8. Templeton TW, Morris BN, Goenaga-Diaz EJ. A prospective comparison of intraluminal and extraluminal placement of the 9-French Arndt bronchial blocker in adult thoracic surgery patients. *J Cardiothorac Vasc Anesth*. 2017; 31:1335–1340.
9. Wald SH, Mahajan MB, Kaplan MB, Atkinson JB. Experience with the Arndt paediatric bronchial blocker. *Br J Anaesth.* 2005; 94:92–94.

10. Liu Z, Zhao L, Jia Q, Yang X, Liang SJ and He W. Chest computed tomography image for accurately predicting the optimal insertion depth of left-sided double-lumen tube. *J Cardiothorac Vasc Anesth.* 2018; 32: 855–

11. Liu Z, He W, Jia Q, Yang X, Liang S and Wang X. The efficacy and adverse effects of the Uniblocker and left-side double-lumen tube for one-lung ventilation under the guidance of chest CT. *EXPERIMENTAL AND THERAPEUTIC MEDICINE.* 2020; 19: 2751–

12. Advanced Life Support Group. Advanced paediatric life support: the practical approach. 3rd ed. *London: BMJ Books.* 2001.

13. Campos JH and Kernstine KH: A comparison of a left-sided Broncho-Cath with the torque control blocker univent and the wire-guided blocker. *Anesthesia & Analgesia.* 2003; 96: 283–289.

14. Sanah Mohtar, Theresa W. C. Hui, Michael G. Irwin. Anesthetic management of thoracoscopic resection of lung lesions in small children. *Pediatric Anesthesia.* 2018; 1–8.

15. Yao Lu, Wei Dai, Zhijun Zong, Yimin Xiao, Di Wu, Xuesheng Liu, Gordon Tin, ChunWong. Bronchial Blocker Versus Left Double-Lumen Endotracheal catheter for One-Lung Ventilation in Right Video-Assisted Thoracoscopic Surgery. *Journal of Cardiothoracic and Vascular Anesthesia.* 2018; 32(1):297–301

16. Borchardt R A, Laquaglia M P, Mcdowall R H. Bronchial Injury During Lung Isolation in a Pediatric Patient. *Anesthesia & Analgesia.* 1998; 87(2):324–325.

17. Disma N, Mameli L, Pini-Prato A, Montobbio G. One lung ventilation with Arndt pediatric blocker for thoracoscopic surgery in children: a unicentric experience. *Paediatr Anaesth.* 2011; 21: 465–467.

18. Narayanaswamy M, McRae K, Slinger P, Dugas G, Kanellakos GW, Roscoe A and Lacroix M: Choosing a lung isolation device for thoracic surgery: A randomized trial of three bronchial blockers versus double-lumen tubes. *Anesthesia & Analgesia.* 2009; 108: 1097–1101

19. Peng Liang, Juan Ni, Cheng Zhou, Hai Yu, Bin Liu. Randomized clinical trial comparing double-lumen tube and Efficacy of a New Blind Insertion Technique of Arndt Endobronchial Blocker for Lung Isolation: Comparison With Conventional Bronchoscope-Guided Insertion Technique-A Pilot Study. *Medicine.* 2016; 95(19): e3678.

20. Campos JH, Hallam EA, Van Natta T and Kernstine KH: Devices for lung isolation used by anesthesiologists with limited thoracic experience: Comparison of double-lumen endotracheal tube, Univent torque control blocker, and Arndt wire-guided endobronchial blocker. *Anesthesiology.* 2006; 104: 261–266.

**Tables**

**Table 1. Demographic characteristics, analgesia, and surgery type in the two groups of patients.**
| Variable                        | The CT group (n=58) | The BRO group (n=61) | P-value |
|--------------------------------|---------------------|----------------------|---------|
| Sex [cases (%)]                |                     |                      | 0.862   |
| Male                           | 41 (70.7%)          | 44 (72.1%)           |         |
| Female                         | 17 (29.3%)          | 17 (27.9%)           |         |
| Age (months)                   | 17.8 ± 8.6          | 17.3 ± 9.6           | 0.820   |
| Weight (kg)                    | 9.91 ± 2.14         | 9.74 ± 2.98          | 0.732   |
| Height (cm)                    | 75.9 ± 19.3         | 76.78 ± 14.12        | 0.773   |
| ASA stage [cases (%)]          |                     |                      | 0.994   |
| ASA I                          | 32 (55.2%)          | 34 (55.7%)           |         |
| ASA II                         | 22 (37.9%)          | 26 (42.6%)           |         |
| ASA III                        | 4 (6.9%)            | 1 (1.6%)             | 0.347   |
| Blocking side [cases (%)]      |                     |                      | 0.302   |
| Left                           | 34 (58.6%)          | 30 (49.2%)           |         |
| Right                          | 24 (41.4%)          | 31 (50.8%)           |         |
| Type of surgery [cases (%)]    |                     |                      | 0.541   |
| Mediastinal mass surgery       | 17 (29.3%)          | 12 (19.7%)           |         |
| Lung surgery                   | 26 (44.8%)          | 27 (44.3%)           |         |
| Diaphragm surgery              | 6 (10.3%)           | 9 (14.8%)            |         |
| Esophageal surgery             | 9 (15.5%)           | 13 (21.3%)           |         |

Table 2. Comparison of endobronchial blocker placement and postoperative recovery between the two groups
| Variable                                                                 | The CT group | The BRO group | P-value |
|-------------------------------------------------------------------------|--------------|---------------|---------|
| Required time for successful blocker placement (s)                     | 124.9 ± 34.2 | 92.9 ± 17.6   | 0.001   |
| Number of repositionings for successful blocker placement              | 1.22 ± 0.56  | 1.05 ± 0.28   | 0.037   |
| The success of the first blocker positioning [cases (%)]               |              |               | 0.011   |
| Yes                                                                     | 48 (82.8%)   | 59 (96.7%)    |         |
| No                                                                      | 10 (17.2%)   | 2 (3.3%)      |         |
| Degree of lung collapse [cases (%)]                                    |              |               | 0.235   |
| Excellent                                                               | 56 (96.6%)   | 61 (100%)     |         |
| Fair                                                                    | 2 (3.4%)     | 0 (0%)        |         |
| Moderate                                                                | 0 (0%)       | 0 (0%)        |         |
| Poor                                                                    | 0 (0%)       | 0 (0%)        |         |
| Grade of airway mucosal injury [cases (%)]                              |              |               | 0.965   |
| None                                                                    | 56 (3.4%)    | 60 (98.3%)    |         |
| Mild                                                                    | 2 (3.4%)     | 1 (1.7%)      |         |
| Moderate                                                                | 0 (0%)       | 0 (0%)        |         |
| Severe                                                                  | 0 (0%)       | 0 (0%)        |         |
| Pulmonary infection within 72 h after surgery [cases (%)]              |              |               | 1.000   |
| Yes                                                                     | 2 (3.4%)     | 2 (3.3%)      |         |
| No                                                                      | 56 (96.6%)   | 59 (96.7%)    |         |
| Trachyphonia after tracheal extubation [cases (%)]                      |              |               | 1.000   |
| Yes                                                                     | 3 (5.2%)     | 3 (4.9%)      |         |
| No                                                                      | 55 (94.8%)   | 58 (95.1%)    |         |
| Duration of postoperative mechanical ventilation (h)                    | 34.3 ± 95.6  | 29.1 ± 62.7   | 0.726   |
| Duration of postoperative ICU stay (days)                               | 2.9 ± 6.3    | 2.5 ± 3.2     | 0.658   |
| Duration of postoperative hospitalization (days)                        | 13.6 ± 11.2  | 13.3 ± 7.6    | 0.882   |
Figure 1

The measure for the distance from the incisor teeth to the carina.
Figure 2

The process to locate the bronchial blocker (The BRO group).
Figure 3

The process to locate the bronchial blocker (The CT group).
Figure 4

Consort flow diagram following the recruitment of 127 patients for analysis.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- CONSORTChecklist.doc