

# CT- 3-Dimensional airway evaluation-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

**Wei Wei**

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](mailto:liuwei19610624@126.com))

---

## Research article

**Keywords:** endobronchial blocker, pediatric anesthesia, CT-3-Dimensional evaluation, one-lung ventilation, bronchoscopy

**Posted Date:** October 15th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-46104/v2>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

**Background:** 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. Computed tomography (CT)-3-Dimensional evaluation 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 evaluation-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 scheduled for 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 hour after surgery, hoarseness 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 hour after surgery, hoarseness 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 evaluation could be used to guide endobronchial blocker placement, with a blocking efficiency similar to that of bronchoscopy-guided blocker placement.

## 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 evaluation-guided endobronchial blocker placement was similar to that of bronchoscopy-guided blocker placement.

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

## Background

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<sup>1-3</sup>. Bronchial blocking is the most commonly used OLV technique for pediatric patients.<sup>4,5</sup> Bronchoscopy (BRO) is commonly used to guide endobronchial blocker placement in pediatric patients<sup>6</sup>. The blocking techniques include

intraluminal and extraluminal blocking<sup>7,8</sup>. However, intraluminal blocking causes less injury with certain blocking efficiency, but 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<sup>9</sup>. 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, how to properly place the endobronchial blocker in pediatric patients remains challenging.

Chest Computed tomography (CT) images could be used to accurately predict the optimal insertion depth of double-lumen tracheal tube<sup>10</sup> and guide extraluminal uniblocker placement in the left bronchus in adult patients<sup>11</sup>. However, the distance from carina to the opening of main bronchus is different between children and adults. 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-Dimensional evaluation 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-dimensional reconstruction and determined the feasibility of applying preoperative helical CT 3-dimensional 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 scheduled for 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) the opening of the right upper lung lobe is parallel to or higher than the carina (Figure 1); (4) patients suspected to have difficulty in laryngoscopy and airway management. (4) uncuffed ETT of 4.5mm could not be inserted. The enrolled patients were randomized into the bronchoscopy (BRO) group and the (CT) group using the closed envelope technique. 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. The endobronchial blocker placement was guided by bronchoscopy in the BRO group and by CT 3-Dimensional airway evaluation in the CT group. All cases of anesthesia were performed by a pediatric anesthetist with 6-year experience of thoracic anesthesia. During the study period, patients were

consecutively recruited and randomly divided into the control or intervention group accordingly. This study was single-blinded. 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:* After sedation, All pediatric patients under sedation preoperative cervical and chest CT scanning (Aquilion 64, Toshiba) at the supine position. lung window was applied to reconstruct coronal and sagittal image with 3mm slice and 3mm slice gap and 512×512 image resolution . The Frankfurt horizontal plane was confirmed with the bilateral auriculares and the right infraorbital margin; the midsagittal plane was confirmed with the middle of sella turcica, the nasion and the posterior edge of foramen magnum. The distance from the incisor teeth to the tracheal carina was measured at the sagittal image when the incisor teeth, the glottis and the whole airway were able to be exposed clearly at the same time. In the case of improper position or the airway compression, MPR( multiplanar reconstruction ) or CPR (curve planar reconstruction)was applied. (Figure 2).

*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<sub>2</sub> 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). When patient was 0.5 -1 years old, uncuffed ETT of 4.5mm was tried to insert. If uncuffed ETT of 4.5mm could not be inserted, the case was excluded. After intubation, the partial pressure of carbon dioxide in endexpiratory gas (PETCO<sub>2</sub>) 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 CT group, CT-3-DimenSional evaluation 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 on (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 repositioning trials, bronchoscopy-guided placement was applied, and the patient was excluded from the study. The proper blocker placement was confirmed by auscultation after the patient was shifted from the horizontal position.

In the BRO group, the insertion depth of tracheal tube was calculated using the classic formula<sup>12</sup>. 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 4). The proper blocker placement was confirmed under bronchoscopy 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 repositioning trials for successful blocker placement (each extubation of the endobronchial blocker from the Trachealtube was counted as one repositioning trial); (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)<sup>13</sup>; (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)<sup>11</sup>; (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) hoarseness 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 Statistical Package for the Social Science (SPSS) 15.0 software (NCSS, Utah, USA) was used for statistical analyses. The test level  $\alpha = 0.05$  and the power was set at 0.8. According to the previous clinical experiences, the difference between groups was moderate ( $w = 0.3$ ). In order to find significant differences between groups, according to the calculation results, each group needs at least 61 subjects ( $n = 122$ ). The demographic data between the two groups was analyzed using independent t test and Chi-squared test, including age, sex, weight, height. The ASA class and thoracic surgery type between groups were analyzed using Chi-squared test. The assessment of blocker operating duration between

groups were evaluated by Chi-squared test including required time for successful blocker placement, repositioning and the successful rate of the first blocker positioning. The effectiveness and prognosis between groups was analyzed using Chi-squared test including degree of lung collapse, grade of airway mucosal injury, grade of airway mucosal injury, pulmonary infection and hoarseness after tracheal extubation. The durations of postoperative mechanical ventilation, ICU and hospitalization was analysis using independent t test. The distribution of data was analyzed using Kolmogorov-Smirnov test. If the data were not of normal distribution ( $p < 0.1$ ), Pearson Chi-squared test with correction or Wilcoxon rank sum test was played. The significant level of differences was set at 0.05.

## 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 were withdrawn from the study after grouping because one-lung ventilation technique was deemed not necessary by the surgeon. Finally, 119 patients were enrolled into this study and subjected to statistical analysis. (Figure 5). The two groups had no significant differences in demographic characteristics, including age, sex, weight, height, ASA class, 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 ( $124.9 \pm 34.2$  s vs.  $92.9 \pm 17.6$  s,  $P < 0.001$ ), successful blocker placement required more repositionings in the CT group than in the BRO group (median [range]: 1[1 to 4] vs. 1[1 to 3]), 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). The degree of lung collapse was excellent in 56 (96.7%) vs. 62 (100%) patients, fair in 2 vs. 0 in the BRO and CT groups, respectively ( $P=0.235$ ). The grade of airway mucosal injury was none in 57 (97%) vs. 60 (98%) patients, mild in 1 vs. 2 in the BRO and CT groups, respectively ( $P=0.965$ ). Pulmonary infection within 72 h after surgery was had in 56 (97%) vs. 59 (97%) patients, not had in 2 vs. 2 in the BRO and CT groups, respectively ( $P=1.000$ ). Hoarseness after tracheal extubation also was not been observed in 58 (95%) vs. 55 (95%) patients ( $P=1.000$ ). In addition, there was no statistically significant difference between BRO and CT groups regarding the durations of postoperative mechanical ventilation ( $29.1 \pm 62.7$  vs.  $34.3 \pm 95.6$ ,  $P = 0.726$ ), ICU stay ( $2.5 \pm 3.2$  vs.  $2.9 \pm 6.3$ ,  $P = 0.658$ ), and hospitalization ( $13.3 \pm 7.6$  vs.  $13.6 \pm 11.2$ ,  $P = 0.882$ ).

## Discussion

The insertion of the **finest** 5F endobronchial blocker requires a Tracheal tube with an internal diameter greater than 4.5 mm<sup>14</sup>. 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 evaluation to measure the airway and guide endobronchial blocker placement. CT-guided endobronchial placement is as effective with similar side effects as direct visualization via bronchoscopy for endobronchial blocker

placement. This technique may be used for patients where intraluminal bronchoscopy for endobronchial blocker placement is impossible, such as neonates and premature infants.

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<sup>15</sup>. 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<sup>16</sup>. 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 hoarseness 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 evaluation to guide endobronchial blocker placement is applicable and safe.

We postulated that CT-3-Dimensional evaluation 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<sup>17</sup>. 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 evaluation-guided endobronchial blocker placement can be used for quick intraluminal blocking.

Narayanaswamy et al.<sup>18</sup> reported that the median time to complete the placement procedures under the guidance of fiberoptic bronchoscopy was 203 seconds, whereas Campos et al.<sup>13</sup> reported a duration of 158 seconds. Peng et al.<sup>19</sup> 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<sup>20</sup>. 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 evaluation 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 evaluation is a simple and efficient technique for endobronchial blocker placement.

## 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

## Abbreviations

computed tomography (CT)

one-lung ventilation (OLV)

intensive care unit (ICU)

bronchoscopy (BRO)

## 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 Fr Arndt 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. *Anaesthetist.* 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 the Herapeutic 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 blockerfor 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	95% confidence intervals	
				Lower	Upper
Age [cases (%)]			0.862		
Sex	41 (70.7)	44 (72.1)			
Duration (months)	17 (29.3)	17 (27.9)	0.820	-2.930	3.695
Weight (kg)	17.8 ± 8.6	17.3 ± 9.6	0.732	-0.782	1.110
Height (cm)	9.91 ± 2.14	9.74 ± 2.98	0.773	-6.712	5.999
Stage [cases (%)]			0.994		
I	32 (55.2)	34 (55.7)			
II	22 (37.9)	26 (42.6)			
III	4 (6.9)	1 (1.6)			
Single side [cases (%)]			0.302		
Left	34 (58.6)	30 (49.2)			
Right	24 (41.4)	31 (50.8)			
Type of surgery [cases (%)]			0.541		
Open surgery (congenital cystic adenomatous malformations; cystic resection; cystic resection with cystic cavity evacuation)	26 (44.8)	27 (44.3)			
Endobronchial surgery	6 (10.3)	9 (14.8)			
Thoracoscopic surgery	9 (15.5)	13 (21.3)			
Open thoracotomy mass surgery	17 (29.3)	12 (19.7)			

A comparison of demographic characteristics, analgesia, and surgery type between the two groups can be found in the Table.

P<0.05 means a significant difference between the two groups.

CT, computed tomography; BRO, Bronchoscopy.

**Table 2. Comparison of endobronchial blocker placement and postoperative recovery between the two groups**

Variable	The CT group (n=58)	The BRO group (n=61)	P- value	95% confidence intervals	
				Lower	Upper
Required time for successful blocker placement (s)	124.9 ± 34.2	92.9 ± 17.6	0.001*	22.262	41.860
Number of repositionings for successful blocker placement	1[1-4]	1[1-3]	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			
Moderate	0	0			
Poor	0	0			
Grade of airway mucosal injury [cases (%)]			0.965		
None	56 (96.6)	60(98.3)			
Mild	2 (3.4)	1(1.7)			
Moderate	0	0			
Severe	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)			
Hoarseness 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	-24.031	34.385
Duration of postoperative ICU stay (days)	2.9 ± 6.3	2.5 ± 3.2	0.658	-1.398	2.204
Duration of postoperative hospitalization (days)	13.6 ± 11.2	13.3 ± 7.6	0.882	-3.204	3.723

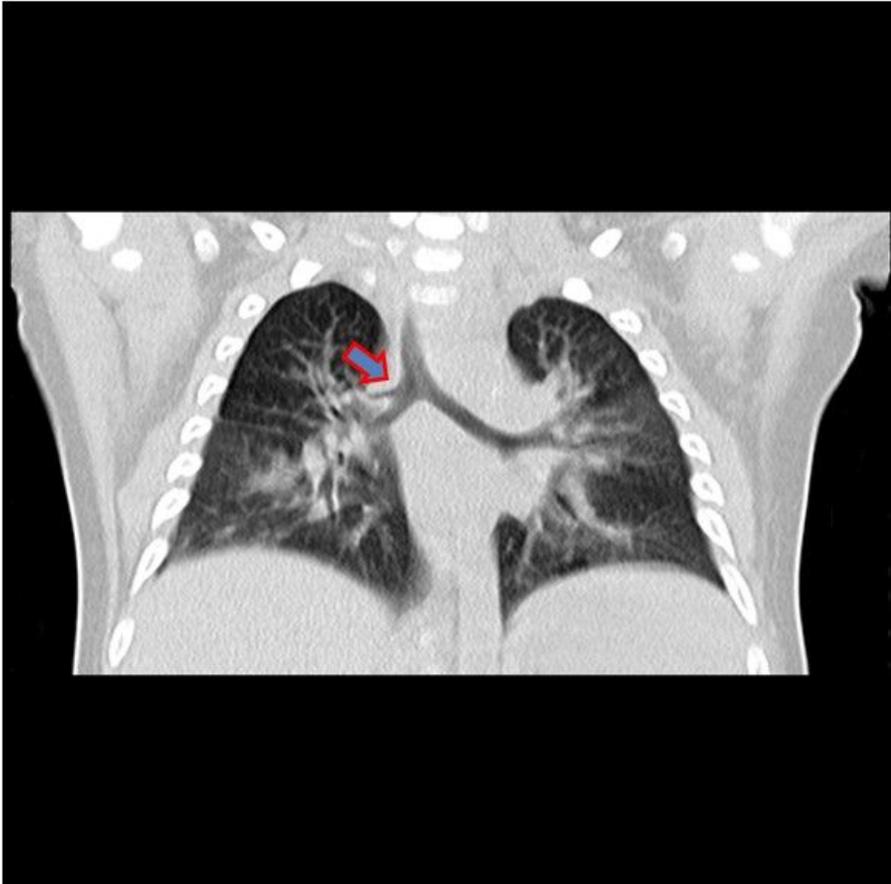
A comparison of endobronchial blocker placement and postoperative recovery between the two groups can be found in the Table.

P<0.05 means a significant difference between the two groups.

\*Statistically significant at p < 0.05

CT, computed tomography; BRO, Bronchoscopy; ICU, intensive care unit.

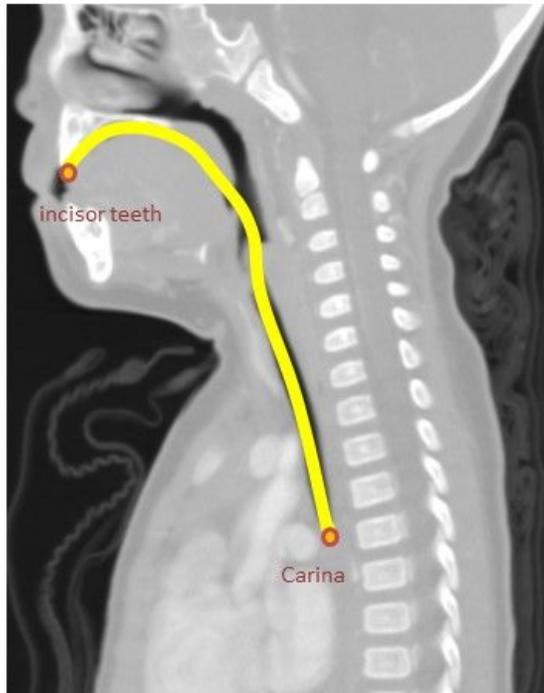
## Figures



**Figure 1 the opening of the right upper lung lobe is parallel to or higher than the carina**

**Figure 1**

the opening of the right upper lung lobe is parallel to or higher than the carina



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

**Figure 2**

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

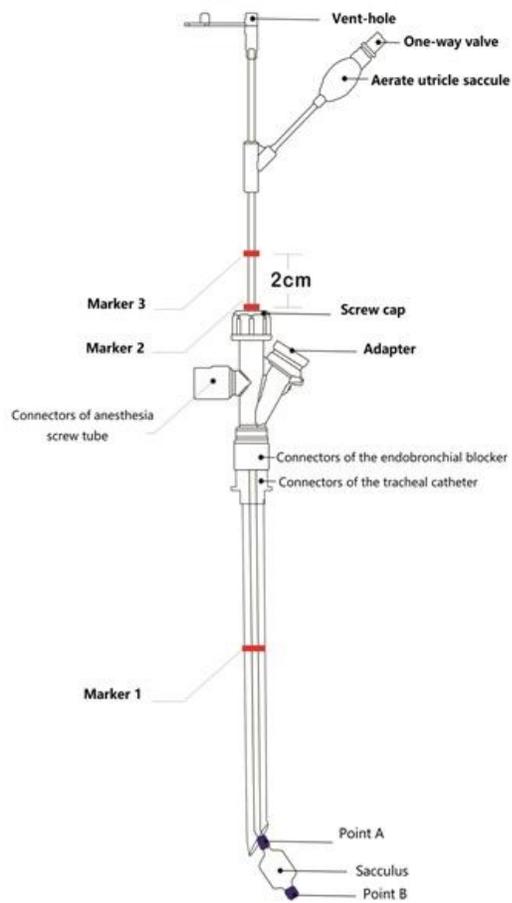


Figure 3a

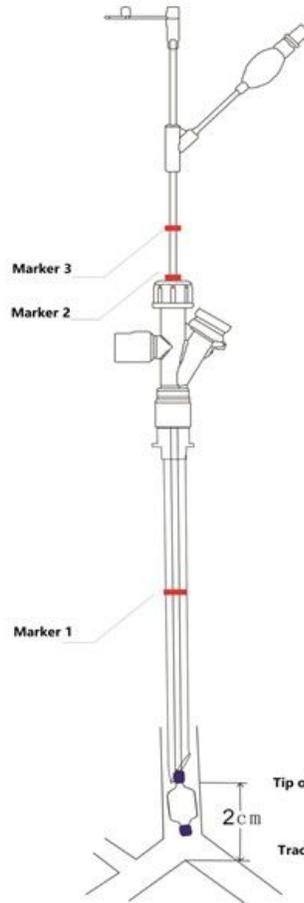


Figure 3b

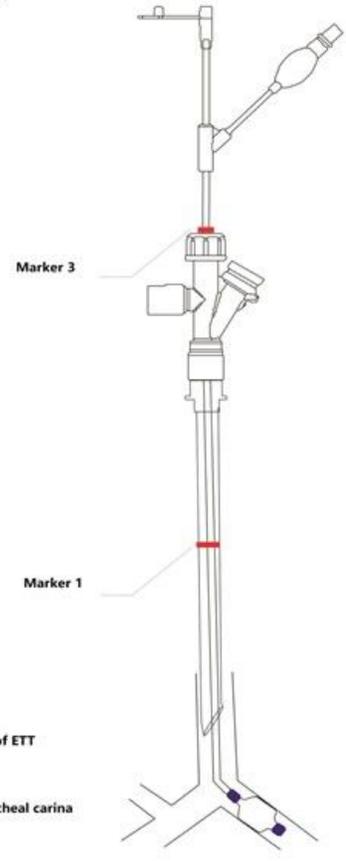


Figure 3c

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

### Figure 3

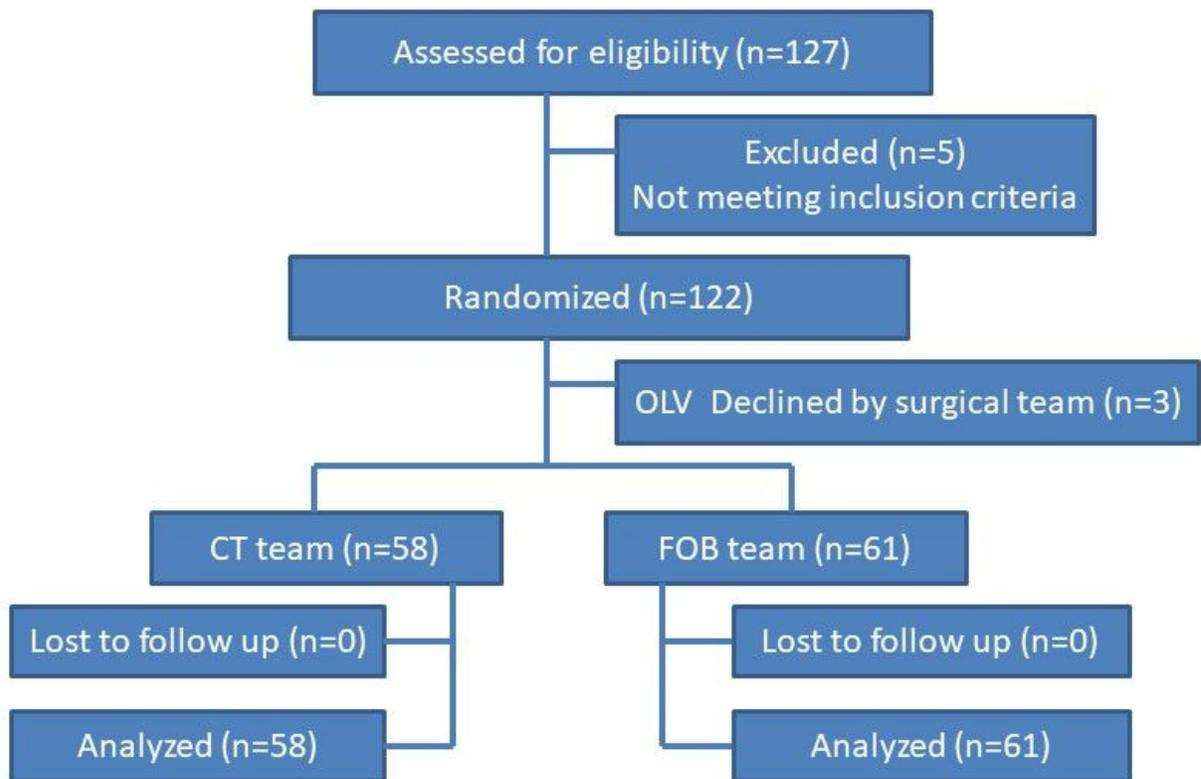
The process to locate the bronchial blocker(The CT group).



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

**Figure 4**

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



**Figure 5** Consort flow diagram following the recruitment of 127 patients for analysis

## Figure 5

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.

- [CONSORT Checklist.doc](#)