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A novel method of Uniblocker placement: extraluminal technique supported by trachea length measurement

A CONSORT-compliant article

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Abstract

Background: The use of bronchial blockers has been increased for one-lung ventilation; however, the placement of bronchial blockers is time consuming. The objective of this study was to compare the novel extraluminal technique of Uniblocker placement supported by trachea length measurement on computerized tomography images with conventional intraluminal Uniblocker placement method.

Methods: Seventy adult patients undergoing left side thoracic surgery were included in the study. All the patients were randomly assigned to one of two groups: conventional intraluminal intubation group (CV-IN group, $n = 35$) or extraluminal CT guided group (CT-EX group, $n = 35$). The primary endpoints were the optimal positions of Uniblocker and the injuries of bronchi and carina. The secondary outcomes included the time of Uniblocker placement, the adequacy of lung collapse, the incidences of Uniblocker displacement, sore throat, and hoarseness postoperative.

Results: In the CV-IN group, 19 of 35 Uniblockers went to the left main-stem bronchus on the initial blind insertion and 15 of 35 Uniblockers were considered as in optimal depth, whereas in the CT-EX group, 32 of 35 Uniblockers went to the left main-stem bronchus on the initial blind insertion and 31 of 35 Uniblockers were considered as in optimal depth ($P < .01$). The incidence of bronchi and carina injuries was obviously lower in the CT-EX group (occurred in 1 of 35 cases) than that in the CV-IN group (occurred in 8 of 35 cases) ($P < .05$). The time of Uniblocker placement took 145.4 s in the CV-IN group and 85.4 s in the CT-EX group ($P < .01$). The malpositions of Uniblocker, the degree of pulmonary collapse and the adverse events postoperative such as sore throat and hoarseness were not significantly different between the two groups ($P > .05$).

Conclusion: The novel extraluminal technique of Uniblocker placement supported by trachea length measurement on computerized tomography images was proved to be more rapid, more accurate and less complications than conventional intraluminal Uniblocker placement method.

Abbreviations: BB = bronchial blocker, CT= computerized tomography, DLT = double-lumen tube, FOB = fiberoptic bronchoscope, IT = intubation time, LDLT = left sided double-lumen tube, OLV = one-lung ventilation, SLT = single lumen tube.

Keywords: chest CT images, one-lung ventilation, Uniblocker

1. Introduction

One-lung ventilation (OLV) is required during the most thoracic surgeries to facilitate surgical visualization by collapsing the lung and the double-lumen tubes (DLTs) are the most commonly used devices for OLV.[1–3] However, the DLTs may be difficult to be placed in patients with difficult airway for its larger diameter and the intubation of DLTs may increase the risk of potential traumatic injury.[4–6] Since the new bronchial blockers (BBs) were introduced, there has been an increase in the use of bronchial blockers for OLV. However, it is not easy to insert the BBs into the left main-stem bronchus using the manufacturer's method.[7,8] Even under direct vision of Fiberoptic bronchoscopy (FOB), the placement of BBs still requires more time compared with the left sided double-lumen tube (LDLT).[9,10] In our previous studies, the author found that extraluminal use of Uniblocker make the repositions of the Uniblocker more easily and less bronchi injuries compared with conventional intraluminal use of Uniblocker[11] and the chest computed tomography (CT) images could accurately predict the optimal insertion depth of LDLT.[12] So the aim of this study was to evaluate the accuracy and feasibility of the novel method of Uniblocker placement: extraluminal technique supported by trachea length measurement on computerized tomography images.

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The authors have no conflicts of interests to declare.

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2. Patients and methods

After approval by the local medical ethics committee of the First Hospital of Qinhuangdao and written informed consent was provided by the patients (Clinical Trials.gov, NCT03008473), 70 adult patients undergoing left side thoracic surgery were included in the study. Exclusion criteria were as follows: age >70 or <18 years; ASA classification >III; BMI >35 kg/m^2; modified Mallampati classification ≥III; thoracic surgery within the last 1 month; severe cardiopulmonary disease.

All the patients were randomly allocated to one of two groups: conventional intraluminal intubation group (CV-IN group, $n=35$) or extraluminal CT guided group (CT-EX group, $n=35$). Randomization (1:1) was based on codes generated by computer and these codes were kept in sequentially numbered opaque envelopes until the end of the study.

All the patients in both groups were screened by a senior anesthesiologist preoperatively. In the operating room, all the patients were placed in supine position and monitored with HR, INBP, ECG, S_PO_2. For anesthesia induction, all the patients were administered midazolam 0.05 $mg\,kg^{-1}$, fentanyl 3 $\mu g\,kg^{-1}$, cis-atracurium 0.2 $mg\,kg^{-1}$, and etomidate 0.3 $mg\,kg^{-1}$. All the patients were intubated exactly 3 min after receiving cisatracurium by an experienced anesthesiologist using one of the two intubation methods.

In the CV-IN group, the intubation steps were conducted as follows: a single lumen tube (SLT) with appropriate size (female: 7.5 mm, male: 8.0 mm) was inserted into trachea at optimal depth via video laryngoscope and inflated the cuff; second, the Uniblocker (Changhua Medical Technology, Chengdu, China) was lubricated with silicone spray, advanced smoothly through the SLT and directed to the left main-stem bronchus until a very slight resistance was encountered; third, an FOB (external diameter 3.8 mm, MDHAO Medical Technology, Zhuhai, China) was inserted into the SLT to assess the position of the Uniblocker and adjust the Uniblocker to an optimal position (Fig. 1G, H), then inflated the cuff of Uniblocker under direct vision of FOB; forth, fixed the SLT to the patient's mouth and fixed the Uniblocker to the end of SLT.

In the CT-EX group, the intubation steps were conducted as follows: the operator counted the number of CT slices (slice thickness is 5 mm) from vocal cord slice to carina slice to calculate the distance between vocal cord and carina (Fig. 1A, B), then measured this distance (the distance between vocal cord and carina measured by chest CT images plus 10 mm) on the Uniblocker from the upper edge of the cuff towards the proximal end of the Uniblocker and marked it (Fig. 1C); second, the Uniblocker was lubricated with silicone spray and inserted into the trachea via video laryngoscope (Fig. 1D). After passing the glottis, the Uniblocker was advanced toward the left main-stem bronchus, once the anesthesiologist saw the marker on the Uniblocker just above the vocal cord, then stopped the insertion (Fig. 1E) and the insertion depth of Uniblocker at the upper incisors was also recorded with a tape mark on the Uniblocker; third, the SLT with appropriate size (female: 7.5 mm, male: 8.0 mm) was intubated via video laryngoscope into the appropriate depth (Fig. 1F) and inflated the cuff with the minimum pressure; forth, the FOB was inserted into SLT to assess the position of the Uniblocker and adjust the Uniblocker to an optimal position if the Uniblocker were not in a right position (Fig. 1G, H), then inflated the cuff of Uniblocker under direct vision of FOB; fifth, the Uniblocker and SLT were fixed to the patient's mouth separately with a cloth tape.

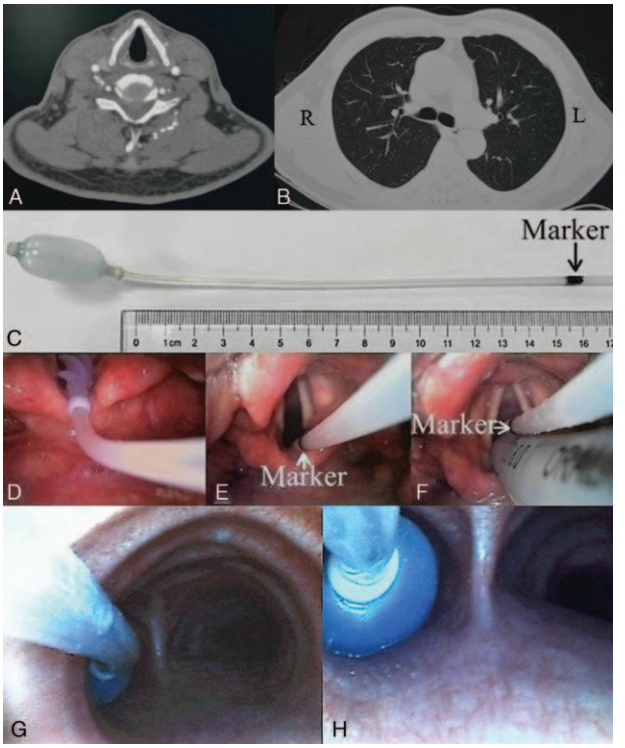

Figure 1. (A) Vocal cord on chest CT image; (B) Carina on chest CT image; (C) Make a marker on the Uniblocker; (D, E, F) Camera view via the video laryngoscope during intubation and the marker on Uniblocker just above the vocal cord; (G, H) The cuff of Uniblocker located below the carina under the view of FOB.

The primary outcome parameters of the study were the number of optimal positions of Uniblocker and the injuries of bronchi and carina assessed by an independent anesthesiologist via FOB after intubation. The secondary outcome parameters were the attempts to adjust the Uniblocker to optimum position, the intubation time (IT) of Uniblocker, the failure of intubations, the adequacy of lung collapse, the incidence of Uniblocker displacement and the occurrences of sore throat and hoarseness 24 h after surgery.

The optimal position of Uniblocker was defined as the upper edge of Uniblocker cuff located appropriately 10–20 mm below the carina in the left main-stem bronchus and the position of the Uniblocker was reconfirmed by FOB after the patients were placed in the lateral decubitus position. The injuries of bronchi and carina were assessed after deflating the cuff of Uniblocker and the degree of bronchi and carina injuries was ranked as 1, clear; 2, a few petechiae; 3, coalesced petechiae, hemorrhage, or ecchymosis; 4, erosion. The intubation time (IT) was defined as the time from the anesthesiologist inserted the video laryngoscope between the teeth of patients until the Uniblocker at the optimal position checked by FOB and the IT was recorded by a nurse using a stopwatch. One repositioning attempt was defined as the Uniblocker went down to the right side during the adjustment and had to be withdrawn for next repositioning attempt. The failure of intubation was defined as inability to insert the Uniblocker into the left main-stem bronchus after 5 attempts. The pulmonary collapse was ranked as excellent, fair or poor by thoracic surgeons who were independent of the study. Malposition occurred during the interval between the completion of intubation and the completion of placing the patients in a lateral

position was an initial malposition. Malposition occurred during the interval between the beginning of surgery and the completion of surgery was an intraoperative malposition.

In this study, based on a pilot study and previous study,[11] the hypothesis was $\mu \neq \mu_0$ (μ was the incidence of bronchi and carina injuries in the experimental group and μ_0 was the incidence of bronchi and carina injuries in the control group) and the sample size required to detect this differences was 66 patients (with the significance set at 0.05, power set at 80%, two-sided test, according to the pilot study, the incidence of bronchi and carina injuries in the control group expected was 40%, and the incidence of bronchi and carina injuries in the experimental group expected was 10%), in addition, we enrolled 4 patients due to the potential risk for the failure of intubation.

Statistical analysis was performed using SPSS 21 statistical software. Continuous variables were summarized using means ± standard deviation (SD) and independent-samples *t*-test was used for the comparison between the groups. Categorical variables were presented as number (percentages) and chi-square test or fisher exact test was used for the comparison between the groups. Rating of bronchi and carina injuries was analyzed using Mann–Whitney rank-sum test. $P < .05$ was considered statistically significant.

3. Results

All the patients were successful for the intubation and no significant differences in patients' sex, age, height, weight, BMI, ASA physical status grade, distance between vocal cord and carina, OLV time and surgery time between the two groups ($P > .05$) (Table 1).

In the CV-IN group, 19 of 35 Uniblockers went to the left main-stem bronchus on the initial blind insertion and 15 of 35 Uniblockers were considered as in optimal depth, whereas in the CT-EX group, 32 of 35 Uniblockers went to the left main-stem bronchus on the initial blind insertion and 31 of 35 Uniblockers were considered as in optimal depth ($P < .01$). In the CV-IN group, 12 of 35 Uniblockers were successful repositioned via FOB on the first attempt and 8 of 35 Uniblockers needed to be repositioned by more attempts, whereas 4 of 35 Uniblockers were successful repositioned via FOB on the first attempt in the CT-EX group ($P = .26$). The incidence of bronchi and carina injuries was obviously lower in the CT-EX group (occurred in 1 of 35 cases) than that in the CV-IN group (occurred in 8 of 35 cases) ($P = .03$). The time of Uniblocker placement was 145.4 seconds in the CV-IN group and 85.4 seconds in the CT-EX group ($P < .01$). The malpositions of Uniblocker occurred in 2 of 35 cases in the CV-IN group (Both cases were intraoperative displacement) and no malposition occurred in the CT-EX group ($P > .05$) (Table 2).

The degree of pulmonary collapse and the adverse events postoperative were not significantly different between the two groups ($P > .05$) (Table 3).

Table 1

Demographic characteristics of patients, distance between vocal cord and carina, one-lung ventilation time and surgery time in the two groups.

	CT-EX ($n=35$)	CV-IN ($n=35$)
Age (years)	53.4 ± 12.4	47.2 ± 16.7
ASA (*n*, I/II/III)	14/15/6	12/19/4
Gender (*n*, M/F)	22/13	23/12
Height (cm)	167.0 ± 7.8	169.8 ± 7.9
Weight (kg)	63.7 ± 10.3	66.4 ± 11.7
BMI (kg/m^2)	22.9 ± 3.6	23.0 ± 3.6
DVC (mm)	126.9 ± 8.7	128.2 ± 9.5
OLV time (min)	95.9 ± 39.0	83.5 ± 71.6
Surgery time (min)	119.7 ± 44.7	108.4 ± 75.9

ASA = American Society of Anesthesiologists, BMI = Body mass index, DVC = distance between vocal cord and carina, OLV = one-lung ventilation, SD = standard deviation.

Table 2

The number of Uniblockers to the left bronchus on initial blind insertion, the number of Uniblockers at optimal position on initial blind insertion, the number of Uniblocker insertion attempts, time to intubation of the Uniblocker, Uniblocker dislodgement and degree of bronchial and carina injuries.

	CT-EX ($n=35$)	CV-IN ($n=35$)	*P*
Number of Uniblocker to the left bronchus on initial blind insertion	32 (91)	19 (54)	<.01
Number of Uniblocker at optimal position on initial blind insertion	31 (89)	15 (43)	<.01
Number of attempts repositioning			
1	4 (11)	12 (35)	.26
2	0 (0)	3 (8)	
3	0 (0)	4 (11)	
4	0 (0)	1 (3)	1
Failed	0 (0)	0 (0)	
Time to intubation (s)	85.4 ± 15.4	145.4 ± 39.0	<.01
Uniblocker dislodgement	0 (0)	2 (6)	.49
Degree of bronchial and carina injuries	1 (3)	8 (23)	.03
1	1 (3)	4 (11)	
2	0 (0)	2 (6)	
3	0 (0)	2 (6)	
4	0 (0)	0 (0)	

Degree of bronchi and carina injuries: 1, clear; 2, a few petechiae; 3, coalesced petechiae, hemorrhage, or ecchymosis; 4 erosion.

4. Discussion

Since the first modern bronchial blocker (BB) called the "Univent tube" was reported by Inoue in 1982,[13] the use of BBs has been increased for OLV.[14–17] However, the most of BBs are placed under direct vision of FOB[18,19] and the placement of BBs is time-consuming. In the study of Campos, the time to initial tube placement (from the tube passed the vocal cords until satisfactory placement of the tube) of Univent BB took 158 seconds.[9] In the study of Narayanaswamy, the intubation time (from the beginning of laryngoscopy to lung isolation) for the Uniblocker was 213 seconds.[10]

Our previous study had shown that extraluminal use of Uniblocker make the repositions of Uniblocker more easily and

Table 3

Degree of pulmonary collapse and the adverse events post-operative of the patients in the two groups.

	CT-EX ($n=35$)	CV-IN ($n=35$)	*P*
Degree of pulmonary collapse			
Excellent	26 (74)	24 (68)	.60
Fair	5 (14)	7 (20)	.53
poor	4 (12)	4 (12)	1.00
Sore throat	9 (26)	7 (20)	.57
Hoarseness	5 (14)	4 (11)	1.00

Degree of pulmonary collapse: Excellent, complete collapse with perfect surgical exposure; Fair, total collapse, but still had residual air; Poor, no collapse was achieved or there was partial collapse with interference of surgical exposure.

less bronchi and carina injuries compared with conventional intraluminal use of Uniblocker[11]; however, the insertion depth of the most Uniblockers still needs to be adjusted. In our another study, the author found that chest CT images could accurately predict the optimal insertion depth of LDLT.[12] So in this study, the author first evaluated the accuracy and feasibility of an innovative approach of Uniblocker placement: extraluminal technique supported by trachea length measurement on computerized tomography images and the results demonstrated that with this method there were more Uniblockers considered as in optimal position on the initial blind insertion (31/35 cases vs 15/35 cases), less intubation time (85.4 s vs 145.4 s) and lower incidence of bronchi and carina injuries (1/35 cases vs 8/35 cases). The likely reasons for higher success rate of Uniblocker in the optimal position on the first attempt and less intubation time in the CT-EX group may be that: First, the left main-stem bronchus continues at a bigger angle and slender than right one, in addition, the trachea does not merely branch in the horizontal plane, but branches posteriorly as well (Fig. 1B).[20] Second, the outer diameter of Uniblocker for adult patients is 3 mm, the outer diameter of FOB is 3.8 mm and the internal diameter of SLT commonly used is 7.5–8.0 mm. In the CV-IN group, both the Uniblocker and FOB needed to be inserted into the lumen of the SLT, so it was difficult to control the Uniblocker and FOB simultaneously within the lumen of SLT. Therefore in the CV-IN group, it was not easy to adjust the Uniblocker to the left main-stem bronchus even under the direct version of FOB, whereas in the CT-EX group, the FOB and the Uniblocker could be pushed and twisted more freely for extraluminal of SLT, so the operator could rotate the Uniblocker with an additional 20° counterclockwise to the left main-stem bronchus to increase the success rate. Third, in the CT-EX group, the operator could accurately calculate the insertion depth relied on the chest CT images. The operator simply saw the marker on the Uniblocker just above the vocal cord via video laryngoscope during intubation the Uniblocker could reach an optimal depth in the bronchus. Because of the above reasons, the intubation time was less in the CT-EX group than that in the CV-IN group. In our previous study, the total intubation time of Uniblocker in the extraluminal used group was 109 seconds,[11] whereas in this study the intubation time of Uniblocker was only 85.4 seconds in the CT-EX group. The reason for this difference may be due to that in previous study, extraluminal use of Uniblocker increase the success rate of the Uniblocker to the left main-stem bronchus on the initial blind insertion; however, the insertion depth of Uniblocker still needed to be adjusted, whereas in this study, the most of Uniblockers to the left main-stem bronchus on the initial blind insertion were also on the optimum depth, because the insertion depth was accurately calculated relied on chest CT images. Less intubation time may reflect the intubation method is more accurately and easily. This point is very important for green hands or under emergency situation.

Recently, Weng and colleagues reported an innovative method for Univent tube placement with the aid of auscultation alone and this method increased the success rate on the first attempt[21]; however, this method needed more intubation time and with higher incidence of bronchus injuries. Hong and colleagues' study reported another method for placing Uniblocker by the change of expiratory tidal volume and peak inspiratory pressure. With this method, it was difficult to direct the Uniblocker to the left main-stem bronchus and the success rate was only 41% on the first attempt.[22]

Displacement of BBs may increase the risk of hypoxia and jeopardize the operation.[10] In the study of Campos and colleagues, malpositions occurred in 1 of 16 cases after turning patients to lateral position using Univent bronchial blockers.[9] In an our previous study, malpositions of Uniblocker after turning patients to lateral position occurred in 2 of 20 cases in FOB intubation group.[11] In the study of Ruetzler and colleagues, malpositions occurred in 7 of 20 cases (both sides thoracic surgery were included) using EZ blocker,[23] whereas in this study the malpositions occurred in 2 of 35 cases in the CV-IN group and no malposition occurred in the CT-EX group. The reasons for this may be as follows: First, this study only selected patients undergoing left side thoracic surgery and the insertion depth of the Uniblocker was 10 mm deeper (the distance between vocal cord and carina plus 10 mm), so when the patients were turned to the lateral decubitus position, the Uniblocker would not dislodge because there was large margin for the Uniblocker to move. Second, during turning patients to lateral decubitus position, Uniblocker and SLT were securely held at the level of the incisors and the patients' heads were kept in the neutral position.

In this study, the lung collapse was rated by surgeons from excellent to poor and there was no significant difference between the two groups. The reason may be that the positions of Uniblocker in both groups were in optimal position before and after turning patients to lateral decubitus position.

The incidence of bronchi and carina injuries may reflect the safety of intubation method. In this study, the injuries of bronchi and carina were 8 of 35 patients in the CV-IN group and only 1 of 35 patients in the CT-EX group. An explanation for this result may be that in the CV-IN group, the Uniblocker needed to be inserted and twisted more time to correct position or reposition than that in the CT-EX group.

In the CT-EX group, the Uniblocker was used extraluminal of SLT, so the Uniblocker and SLT may cause compression effect on the vocal cord; however, the results of our previous study[11] and this study have shown that the incidences of hoarseness and sore throat postoperative have no statistical differences between two groups. An explanation for these results may be that the glottis is a narrow crack and the Uniblocker is very thin (Fig. 1F), so the compression caused by Uniblocker and SLT may be very slightly, in addition all the intubations of Uniblocker were performed by an experienced anesthetist in this study to reduce the bias by operators with different levels of intubation skill.

There are some limitations in our study. First, this method does not apply to patients whose glottis are invisible during intubation, in addition, preoperative chest CT scans must contain the carina slice and vocal cord slice. Second, it was not possible to blind investigator to the technique, consequently we cannot rule out the possibility of biases by investigator in this study. Third, the overall sample size was small. Forth, we did not used neuromuscular monitoring during intubation which may influence the results. Fifth, we could only assess the injuries of carina and part of left side bronchus after intubation for the lesions can be hidden by the tube.

In conclusion, the novel extraluminal technique of Uniblocker placement supported by trachea length measurement on computerized tomography images was proved to be more rapid, more accurate and less complications than conventional intraluminal use of Uniblocker method.

Author contributions

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Validation: Zhuo Liu.
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Writing – Review & Editing: Zhuo Liu, Xiaochun Yang.

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