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Efficacy of a New Blind Insertion Technique of Arndt Endobronchial Blocker for Lung Isolation

Comparison With Conventional Bronchoscope-Guided Insertion Technique—A Pilot Study

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Abstract: This study aimed to find other methods of blind insertion of Arndt endobronchial blocker (AEB) for lung isolation when a fiberoptic bronchoscope (FOB) is unavailable.

We compared the effectiveness and safety of 3 insertion techniques of AEB: Gum elastic bougie (GEB)-, bougie combined with cricoid displacing (BCD)-, and fiberoptic bronchoscope (FOB)-guided insertion. Seventy-eight patients undergoing esophageal procedure and requiring left thoracotomy were randomly assigned to 1 of 3 groups: GEB group, BCD group, and FOB group. We recorded the successful placement of AEBs at first attempt, placement time, malposition of AEBs in supine and lateral decubitus position, the bronchus injury score, and other complications.

The successful placement of AEB for the first attempt was 22/26, 25/26, and 26/26 patients in GEB, BCD, and FOB groups, respectively. The placement times in GEB and BCD groups were longer than those in the FOB group ($P < 0.05$). AEB malposition occurred in 1/26, 2/26, 1/26 patients after lateral decubitus position, and AEBs were repositioned in 5/26, 3/26, 1/26 patients by FOB due to poor lung isolation in GEB, BCD, and FOB groups, respectively. There was no difference for the bronchus injury scores and other complications among 3 groups ($P > 0.05$).

Bougie and cricoid displacing-guided blind insertion of AEB seems to be a novel method, which is an effective and safe alternative when FOB was unavailable.

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Abbreviations: AEB = Arndt endobronchial blocker, BBs = bronchial blockers, BCD = bougie combined with cricoid

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PL and JN did the study design, patient recruitment, data collection, data analysis, and article preparation. HY and BL designed the study and conducted the study. CZ analyzed the data and prepared the manuscript.

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displacing, ChiCTR = Chinese Clinical Trial Register, DLT = double-lumen endotracheal tube, ETT = endotracheal tube, FOB = fiberoptic bronchoscope, GEB = Gum elastic bougie, OLV = one-lung ventilation.

INTRODUCTION

Lung isolation techniques are designed to facilitate lung exposure and achieve one-lung ventilation (OLV) in patients undergoing thoracic, mediastinal, vascular, or esophageal procedures.¹ OLV is most often provided using conventional double-lumen endotracheal tubes (DLT).² An alternative for providing OLV is the use of a bronchial blocker (Univent [Vitaad Ltd., Lewiston, NY] torque control blocker).³ The wire-guided endobronchial blocker (Arndt blocker; Cook Critical Care, Bloomington, IL) is a tool that has been developed to allow for endobronchial blockade.⁴ This blocker contains a guide wire loop that allows the endobronchial blocker to be coupled to a pediatric fiberoptic bronchoscope (FOB) to facilitate placement by acting as a guide or stent after navigating the airway. Routinely, FOB is used to guide and confirm Arndt endobronchial blocker (AEB) position. It is imperative that an AEB be safely and accurately positioned because a misplaced or improperly used blocker can jeopardize any operation or injure the patient. However, are there any other methods to be used for blind insertion of AEB when an FOB is unavailable or when its use is difficult?

Gum elastic bougie (GEB) is a tracheal tube introducer, flexible device with a J angle at its distal tip, which is usually used to guide and ease insertion of the ProSeal laryngeal mask airway or the endotracheal tube.^{5,6} The J angle tip of GEB can be easily inserted into left or right bronchus and would be a replacement of FOB to guide AEB insertion. But sometimes it is very difficult to insert the blocker into the target bronchus with the guidance of GEB or FOB. Fukuyama et al described a new method which enabled easy blind insertion of the blocker of Univent tube into the left bronchus by cricoid displacing maneuver.⁷ We hypothesized that the combination of GEB with this maneuver would be a more suitable method for blind insertion of AEB. This prospective study was designed to determine whether a simple blind maneuver GEB or bougie combined with cricoid displacing (BCD) could substitute FOB guidance for AEB insertion in esophageal surgery requiring left thoracotomy (Figure 1).

METHODS

Participants

The study protocol was registered in Chinese Clinical Trial Register (ChiCTR) (ChiCTR-IOC-14005313, <http://www.chictr.org.cn/index.aspx>). After approval by the institutional

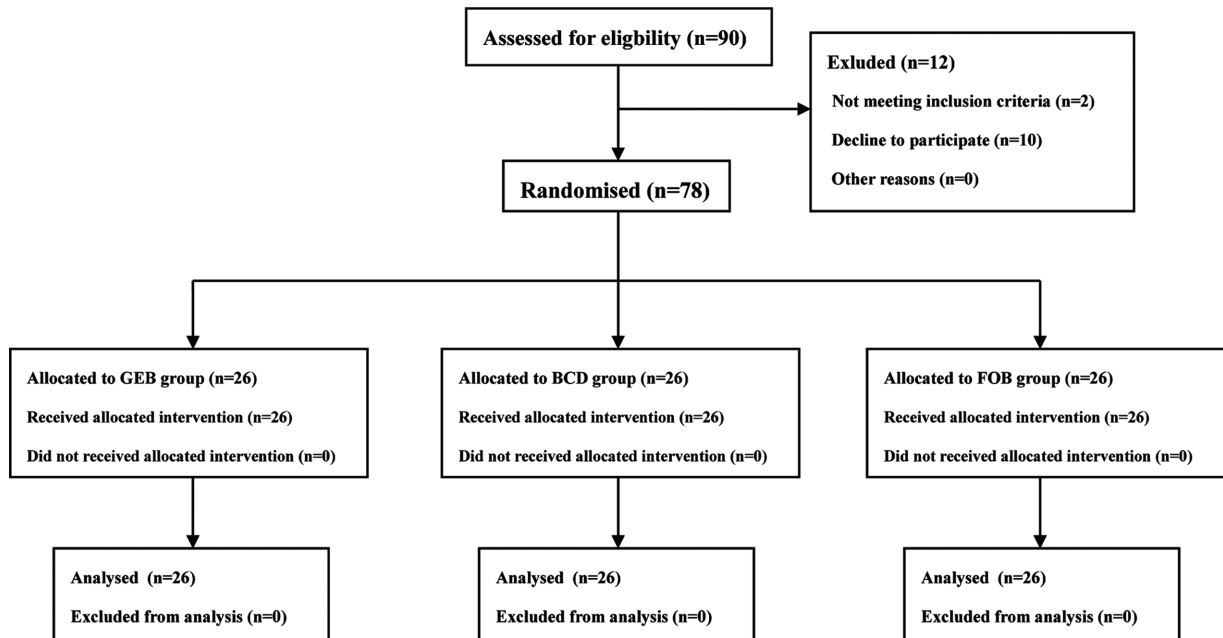


FIGURE 1. Flow diagram of the study.

ethics Committee of West China Hospital of Sichuan University, written informed consent was obtained from each of 78 patients underwent esophageal procedure requiring left thoracotomy. Patients were randomly assigned immediately before induction of anesthesia by a table of random numbers originated from SPSS 18.0 to 1 of 3 groups: GEB group, BCD group, and FOB group.

Anesthesia Protocol

On arrival at the operating room, all patients received a standard premedication of 0.2 mg atropine and 0.03 mg/kg midazolam intravenously ~30 minutes before the induction of general anesthesia. Atropine was administered as an anticholinergic to permit optimal visualization with the FOB. Routine monitoring included electrocardiography, pulse oximetry, non-invasive arterial blood pressure, capnography, and body temperature. Following preoxygenation for 3 minutes, sufentanil (0.3 μ g/kg) and propofol (2 mg/kg) were intravenous administered for induction. Rocuronium bromide (0.6 mg/kg) was injected to facilitate endotracheal intubation. After induction of anesthesia, the patients were intubated with either an 8.0-mm (males) or 7.5-mm (females) internal diameter endotracheal tube (ETT) by a Macintosh 3 laryngoscope.

AEB Insertion Techniques

The AEB (Arndt endobronchial blocker set, Cook Critical Care, Bloomington, IL) is a 7 Fr catheter with a removable string that loops over a 3.4-mm fiberoptic scope (FOB; BF type 3 C40; Olympus, Tokyo, Japan). The FOB and the blocker were inserted through each respective ports of the multiport airway adapter. Then we looped the inner filament at the end of the blocker with the FOB end together. Finally, the multiport airway adapter was connected to the tracheal tube and airway circuit. In the FOB group, prior to placement, the AEB shaft

and the fiberscope are lubricated with jelly. The fiberscope was withdrawn from the wire loop after the deflated cuff of AEB was below the entrance of the bronchus. The optimal position of the AEB in the left bronchus was confirmed by the fiberscope after the blocker balloon inflated, with its outer surface being seen on the left bronchus and at least 2 to 5 mm below the carina.

In the GEB group, the FOB was replaced by the GEB. The J shape tip of GEB was rotated to the target main bronchus during insertion. The AEB position was checked by stethoscope and the depth of AEB was estimated by the formula for the placement of DLT^{8,9} (Figure 2).

In the BCD group, the cricoid displacing maneuver described by Fukuyama et al was performed when AEB insertion was guided with GEB. The cricoid displacing maneuver of inserting the blocker into the left main stem bronchus will be described. The head of the patient was moved to the left and the cricoid was pressed toward the right. As the displacement of larynx toward the right, the tip of blocker will be inserted into the left main bronchus. We also checked the AEB position by a stethoscope.

In both GEB and BCD groups, if the AEB failed to advance into target main bronchus for the first time, the FOB would be used to guide AEB for the second time. Finally, the FOB was performed to recheck the position of AEB after the successful insertion in GEB and BCD groups. We recorded the malposition in the supine position but did not reposition AEB (Table 1).

The balloon was deflated after placement of AEB and inflated again before starting OLV after the patients turned into a right lateral decubitus position. Then another FOB examination was performed for all patients and the AEB malposition in the right lateral decubitus position was also recorded. Reposition with the FOB was only performed when poor lung isolation.

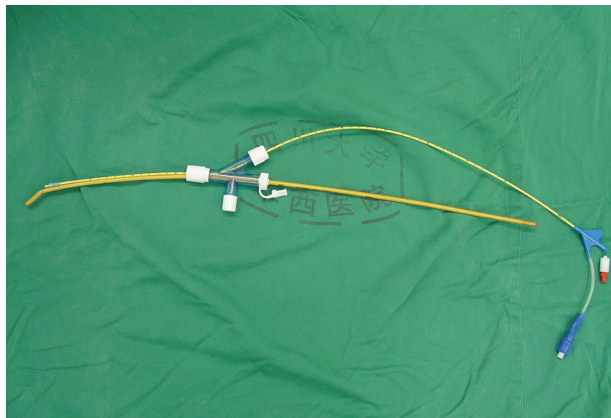


FIGURE 2. String of AEB loops over the J shape tip of GEB. AEB = Arndt endobronchial blocker, GEB = Gum elastic bougie.

Study End Points

We compared the effectiveness of 3 techniques considering: (1) the number of successfully placement for the first attempt, (2) the time needed for insertion, (3) AEB malposition in supine and lateral decubitus position, and (4) number of reposition by the FOB during surgery. We also assessed the safety of each group including laryngospasm, stridor, teeth damage, the bronchus injury score, sore throat, and hoarseness.

Bronchus Injury by Bronchoscopic Examination

Upon completion of surgery, all patients underwent a bronchoscopic examination before the emergence from anesthesia. Bronchus injury from the FOB was classified by the scoring as follows: 0, no changes; 1, redness; 2, edema; and 3, hematoma.¹⁰

Sore Throat 24 hours After Surgery

At 24 hours after surgery, a blinded investigator assessed the complications of patients, including the incidence and intensity of sore throat. The intensity of sore throat was graded 1 – 3 as follows^{10,11}: 1, mild (pain with deglutition); 2, moderate (constant pain and exacerbation with deglutition); 3, severe (pain interfering with eating and requiring analgesic).

Power Calculation and Data Analysis

The sample size was calculated according to the data of Campos and Kernstein,¹² which showed a mean time for placement of the AEB at 200 seconds. With a clinically relevant difference in mean placement of 60 seconds, 25 patients were required each group based on the power of 0.95 and an α error of 5%. In this study, 26 patients were recruited to each AEB placement technique group.

TABLE 1. Malposition Criteria

Bronchial cuff herniated into carina
Bronchial cuff edge not visible in the entrance of the mainstem bronchus
Intraoperative reposition of the tube needed because of poor lung isolation
Arndt blocker in the opposite bronchus

All data are presented as mean \pm SD or the number. Data were tested for normal distribution using the Kolmogorov–Smirnov test. Comparison of nonparametric data was performed using Fisher’s exact test. Parametric data were analyzed using unpaired *t*-test. $P < 0.05$ was considered statistically significant difference. All statistical analyses were performed by SPSS 18.0 for Windows (SPSS, Chicago, IL).

RESULTS

After screening 90 prospective patients, 2 patients did not meet the inclusion criteria and 10 patients refused to participate. A total of 78 patients undergoing esophagus surgery via left thoractomy were finally enrolled. There were no significant differences among 3 groups in the demographic characteristics as listed in Table 2.

For the first attempt, the placement of AEB succeeded in 22 of 26 patients in the GEB group and 25 of 26 in the BCD group as confirmed by stethoscope. Five AEBs were initially inserted into the right main bronchus and proved successful lung isolation with the help of the FOB secondly. All AEBs were successfully inserted into the left bronchus for the first attempt in the FOB group. Four AEBs were malposition in 3 groups (2 in the BCD group, 1 in both GEB and FOB groups) with the patient position changed to the right lateral decubitus position. The placement time in the FOB group was less than that in GEB and BCD groups (185 \pm 10.6 seconds in the FOB group, 267 \pm 13.7 s in the GEB group, 260 \pm 20.2 in the BCD group, $P < 0.05$) (Table 3).

There were no complications such as severe tracheobronchial hemorrhage, tracheobronchial perforation, and arytenoid dislocation in all patients. There was no significant difference in bronchus injury scores among 3 groups (Table 4).

DISCUSSION

This study demonstrates a new effective blind insertion of AEB that is very suitable when the FOB is unavailable or inapplicable. The GEB is very commonly used in clinical practice. Cricoid displacing maneuver is easy and safe and can be used in lung isolation. The GEB combined with cricoid displacing maneuver can facilitate the insertion of the AEB into the target bronchus similar to FOB with no increased trauma and may be a better choice in comparison with single GEB.

Some potential complications from DLTs, such as hoarseness, bronchus injury, and sore throat, have been reported.^{10,13} Furthermore, it is difficult in positioning in patients with abnormal upper or lower airway anatomy, especially for right DLTs,¹⁴ and in patients with difficult airways.^{15,16} There has been a recent increase in use of bronchial blockers (BBs) for OLV because of increased surgical procedures requiring lung isolation, decreased injury risk, and no requirement of change to a single-lumen ETT at the completion of surgery if the patient requires postoperative ventilatory support.^{17–21} AEB, as a new blocker, was first reported to be applied in 1999.⁴ Now, the AEBs are also commonly used in pediatric anesthesia and in combination with a laryngeal mask.^{22,23} The conventional insertion of AEB involved FOB guidance, which is a standard and effective method. However, FOB is unavailable or inapplicable in most hospitals of China. Meanwhile, inappropriate sterilization of FOB also contributes to perioperative infection. A single-lumen tube with blind AEB insertion may be an alternative to the FOB-guided method when the FOB is unavailable. But it is usually failed to achieve the left main bronchus blockade and potential bronchus injury is a concern.

TABLE 2. Demographic Data of Patients

	Group GEB	Group BCD	Group FOB
Age, y	56 (37–74)	57 (44–70)	55 (39–71)
Gender (M/F)	14/12	18/8	13/13
ASA grade (1/2/3/4)	6/17/3/0	8/14/4/0	6/18/2/0
Weight, kg	65.2 (12.3)	66.1 (11.0)	65.3 (14.1)
Height, cm	166.4 (9.2)	167.1 (10.3)	167.2 (9.5)
Mallampati class (1/2/3/4)	7/12/6/1	9/14/2/1	5/16/5/0

BCD = bougie combined with cricoid displacing, FOB = fiberoptic bronchoscope, GEB = Gum elastic bougie.

TABLE 3. The Effectiveness of 3 Different Placements of AEBs

	Group GEB	Group BCD	Group FOB
Successful placement at first attempt	22/26	25/26	26/26
Placement time, s	267 ± 13.7	260 ± 20.2	185 ± 10.6
Malposition in supine position	4/26	1/26	0/26
Malposition in lateral decubitus position	1/26	2/26	1/26
No. of reposition	5/26	3/26	1/26

AEB = Arndt endobronchial blocker, BCD = bougie combined with cricoid displacing, FOB = fiberoptic bronchoscope, GEB = gum elastic bougie.

TABLE 4. The Safety of 3 Different Placements of AEBs

	Group GEB	Group BCD	Group FOB
Laryngospasm	0/26	0/26	0/26
Stridor	0/26	0/26	0/26
Teeth damage	0/26	0/26	0/26
Sore throat	4/26	5/26	5/26
Intensity of sore throat (1/2/3)	2/2/0	4/1/0	3/2/0
Hoarseness	2/26	1/26	2/26
Bronchus injury score	0.83 ± 0.18	0.97 ± 0.29	0.87 ± 0.11

AEB = Arndt endobronchial blocker, BCD = bougie combined with cricoid displacing, FOB = fiberoptic bronchoscope, GEB = gum elastic bougie.

The J shape tip of GEB is easily passed through the glottis and into the target bronchus by left or right rotation of ninety degrees. Sometimes, it is very difficult to insert the blocker into the left main bronchus blindly. Fukuyama et al reported a blind endobronchial insertion of a movable bronchial blocker by turning head to the same side and displacing the cricoid to the contrary side.⁷ Although the efficacy of AEB have been reported,²³ there has been no prospective study comparing the effectiveness of AEB blind insertion by the guidance of GEB or GEB combined with cricoid displacing maneuver.

In our study, 22/26 AEBs were successfully blindly inserted into the left bronchus by the guidance of GEB for the first attempt. As we have known, sometimes it is difficult for left bronchus insertion because of the bigger angle with trachea. The cricoid displacing maneuver originated by Fukuyama et al⁷ is a very effective method for blind left bronchus insertion.

Combined GEB with cricoid displacing maneuver, 25 of 26 patients in our study had successful left lung isolation with AEB for the first attempt. The results of our study demonstrate that the placement of AEB without the aid of FOB (blind insertion) is less successful under GEB guidance but is very effective under the guidance of GEB combined with cricoid displacing maneuver.

For blind insertion of blocker, it is important to calculate the insertion depth of AEB. The depth of 25 of 60 (40.17%) our patients was within the range of optimal depth ± 0.5 cm as calculated with the formula of DLT (12 + [patient height/10] cm).^{8,9} The height is not a good predictor of DLT insertion depth in some individuals with a shorter stature (< 155 cm) of Asian descent.²⁴ In our study, there was still a significant correlation of insertion depth with height of patients.

Sore throat and hoarseness are well-known postoperative complications after tracheal intubation.²⁵ Zhong and colleagues reported the incidence of sore throat of different bronchial blockers (Coopdech 13%, Arndt 20%, and Univent 30%).²⁶ In this study, the incidence of sore throat and hoarseness was not up to 20% and there was no difference among 3 groups. The reason is likely due to the small sample size, endotracheal tube's size, and intubation skills. In addition, GEB is rigid and with the potential risk of bronchus injury, especially combined with the cricoid displacing maneuver. As an assessment of the complications 24 hours after surgery, there was no patient suffered from arytenoid dislocation, tracheobronchial hemorrhage, and tracheobronchial perforation. For bronchoscopic examination by the FOB, there was no significant difference in bronchus injury scores among 3 groups. Thus, the GEB with or without cricoid displacing maneuver guided AEB insertion may be a safe method.

A limitation of this study is the small sample size to assess the sore throat, hoarseness, and the airway injury. In future studies, we will assess the effectiveness of the cricoid displacing maneuver used in DLT and Univent intubation.

CONCLUSIONS

The GEB combined with cricoid displacing maneuver-guided insertion of AEB is an efficient, safe, and alternative to the FOB-guided method to provide lung isolation to enable thoracic surgery.

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